VOL V NO 6

THE JOURNAL OF THE SOCIETY OF AUTOMOTIVE ENGINEERS

DECEMBER 1919

SOCIETY OF AUTOMOTIVE ENGINEERS INC.
29 WEST 39TH STREET NEW YORK

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HIGH SPEED
NON-GRAN
BEARING BRONZE

THE

JOURNAL
OF THE SOCIETY OF
AUTOMOTIVE ENGINEERS

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CHAS. M. MANLY, *President* COKER F. CLARKSON, *Secretary* C. B. WHITTELSEY, *Treasurer*

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Business Is Business

By BERTON BRALEY

Reprinted from The Nation's Business

"Business is Business," the Little Man said,
"A battle where 'everything goes,'
Where the only gospel is 'get ahead,'
And never spare friends or foes;
'Slay or be slain,' is the slogan cold,
You must struggle and slash and tear,
For Business is Business, a fight for gold,
Where all that you do is fair!"

"Business is Business," the Big Man said,
"A battle to make of earth
A place to yield us more wine and bread,
More pleasure and joy and mirth;
There are still some bandits and buccaneers
Who are jungle-bred beasts of trade,
But their number dwindles with passing years
And dead is the code they made!

"Business is Business," the Big Man said,
"But it's something that's more, far more;
For it makes sweet gardens of deserts dead,
And cities it built now roar
Where once the deer and the gray wolf ran
From the pioneer's swift advance;
Business is Magic that toils for man,
Business is True Romance.

"And those who make it a ruthless fight
Have only themselves to blame
If they feel no whit of the keen delight
In playing the Bigger Game,
The game that calls on the heart and head,
The best of man's strength and nerve;
"Business is Business," the Big Man said,
"And that Business is to **Serve!**"

WYMAN-GORDON COMPANY

Worcester, Massachusetts

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Recent Action Regarding the Sections

THE 1919 Sections Committee, of which C. S. Crawford was chairman, and Joseph A. Anglada, W. A. Brush, H. R. Corse and C. S. Whitney were members, did much valuable work in connection with the methods of conducting the Sections of the Society. Several meetings were held in the different automotive centers, including conferences with the Society Membership Committee whose work is closely inter-related with the activities of the local working units of the Society. Members of both committees advised repeatedly with the officers of the Society at Council meetings. Practically all the features of the Sections' work were discussed, with the result that a definite program which has several new features has been evolved.

A manual, upon which study has been concentrated for about two years, has been approved by the Council and issued in final form for use by the Sections in the carrying out of details of office work and procedure in meetings. The manual is an outline scheme of the different steps to be taken by the Sections from time to time and constitutes, it is generally agreed, a helpful vade-mecum for the Section officers.

Enrollment of Section Associates to Cease

Some years ago there was authorized under a Council ruling the enrollment of Associates by the Sections. The original thought was to serve those men who wished to participate in Section meetings but who could not afford to join the Society and thereby become eligible for membership in a Section. The Section Associate was not a member of the Section or of the Society but had certain restricted privileges. It was believed that a properly enrolled body of Section Associates would result in the recruiting in due course of additional members for the Society with mutual benefit to the Society and the men engaged in automotive engineering work. After a long trial, however, it is the practically unanimous opinion of those well qualified to judge that it is better to discontinue the enrolling of Associates by the Sections. One point not fully appreciated heretofore is that in the case of men under 26 years of age there is a better opportunity to obtain the benefits of affiliation with the Society by joining as Junior members thereof, in view of the low initiation fee and annual dues in effect currently for this form of membership. Such men if engaged in engineering work are eligible for Junior membership in the Society, the initiation fee being $10 and the annual dues $5. The standard annual dues for Section membership are $5, whereas the standard fee for enrollment as Section Associate was $10. It is to be borne in mind that the Junior member receives all of the privileges of the Society, including its publication, except voting power. The only privilege which a Section Associate received, in addition to that of attending Section meetings, was the receipt of the JOURNAL of the Society.

After mature consideration of all the circumstances, the Society Council has voted to request the Sections to cease enrolling Associates during this fiscal year, and to amend their Constitutions so that Section enrollment will thereafter be eliminated.

To make more accurate maintenance of the records of the Sections possible and to relieve materially the burden upon the officers of the Section, the policy has been instituted of each Section maintaining a paid Assistant Secretary on part or whole time. An action more or less intimately associated with this policy is to the effect that the restriction in the Standard Section Constitution preventing immediate re-election of a Section Secretary shall be eliminated.

Section Dues to Be Continued

Considerable discussion was had as to the advisability of discontinuing the provision for the payment of Section dues by those members of the Society becoming Section members. It has been decided that in the present circumstances at least it is better that these dues be continued. This point is based in part upon the feeling that the abolishing of Section dues would have a harmful effect on the integrity of and interest in the Section, and in part upon the financial problems that would be evolved for the Society if the Section dues were abolished, there being of course no thought of reducing in any way the activities of the Section. The Sections are plainly a part of the life-blood of the Society.

As to the defrayal of Sections expense from the Treasury of the Society, the Council has appropriated for the use of the Sections each year moneys in the following amount: $250 to be received by each Section at the beginning of the standard fiscal year, Oct. 1, and in addition $1 for each member of the Section as of March 1 of each year.

Plans have been completed for regular and increased service to the Sections from the Society.

The Airplane As a Commercial Possibility

By D. W. Douglas[1] (*Member*) Cleveland Section Paper

THE cessation of the great war has left the airplane industry in America well equipped to design and produce machines and engines of the highest quality in the world. It has, however, left it in poor shape for existence, for few of the airplanes developed for military purposes hold much promise of successful adaptation to peace-time commercial uses. Future military business of any magnitude is problematical. That the war has advanced the science of aeronautics and in a way that will help to solve even the commercial problems is true; and it has given the industry opportunities for the betterment of its products that would not have come to it in double the period of time in peace. That commercial use must be made of airplanes to support even a part of the capital and interests involved in the business at present, seems necessary.

Many people argue that the Government cannot afford to allow this great and new industry to languish because of lack of business, but must foster and further it by subsidy or continued military orders. That such a course would be welcome at this critical period is undeniable, but total dependence of existence on this problematic possibility would be fatal. Governments are sometimes slow in acting in a sufficiently decisive manner on such problems, as is witnessed by the disappearance of our merchant marine in the latter part of the nineteenth century. Furthermore, government subsidy does not always appear healthy for the sound development of commercial projects. Of the early transcontinental railroads, those that received the least or none of the support accorded by the Government remained the most financially sound.

The problem before us today is: What practical use can be made of airplanes, what volume of business can we expect to secure with them, what changes of or developments from present military machines will be necessary to give us an efficient commercial machine, and what does the future hold for this new means of transportation? Let us inquire into the probable fields that the commercial airplane can hope to enter, and, either competing successfully with other means of transportation or supplying the lack of such transportation, become a recognized factor in the development of commerce and the furtherance of social and economic intercourse throughout the world.

Passenger Transportation

Since speed is the most outstanding present-day advantage of the airplane, I rank passenger carrying first in importance. Many of our daily business and personal affairs can be successfully conducted only by a personal meeting or inspection. Correspondence, telephony and telegraphy cannot supply the complete satisfaction of actual personal contact. Where any great distance separates the subject and his objective, present-day express train service often proves too slow.

Time wasted in travel means money lost, suffering endured or pleasure sacrificed. Granted safety comparable with that of our present means of travel, in point of fatalities per miles traveled, and that I trust will be demonstrated soon, are there not many instances in the life of any person when he would gladly pay twice the railroad fare to reduce his travel time to one-half or one-third? Is it not conceivable, then, that having once found that this saving is worth something to him at a critical time, he will avail of it again for some less important reason? Soon he will find, if he be a man of large and pressing affairs, that he is remolding his schedules on the basis of this new time-annihilating service. The first problem, then, seems to be to win the confidence of the public, to institute a successful passenger transportation line between two great cities such as New York and Cleveland.

Aeronautical people all feel confident that with the lessons learned from military experience and with new safeguards thrown around the airplane in its operation and maintenance, such a service can be safely embarked on with our present-day knowledge and material. This must be proved by actual performance rather than by statement, and so the airplane builders or those with the necessary knowledge, enthusiasm and capital who will come forth as commercial operators must take the risk. In one way or another they must actually carry passengers. They must carry them on schedule, comfortably and without mishap, and for a reasonable period of time. Experimental human material is needed, then, in addition to the experimental carriers of it. To my way of thinking, and from observation of and conversation with many people, there is plenty of such material in the adventurous, the curious and those whose extremity may be so great as to warrant the chance they are sure to believe they are taking at the time.

Granted, then, that sufficient patronage of a not too serious order can be counted on for starting a passenger-carrying airplane line of small size, what form will this first venture assume? Three methods of attack can be followed and are being followed at this time. They are:

(1) Scheduled regular service
(2) Special taxi service
(3) Tourist service

Of the three the first seems to hold the most promise of giving us our first real data on costs, maintenance and traffic. While it appears offhand to involve the risking of more capital than the last two, it need not preponderate greatly in this respect and certainly will offer a more accurate count of the public pulse than the other methods. By scheduled service I mean, of course, the operation of one or more machines flying between two or more points on a time schedule properly based on the safe speed of the plane, the altitude flown and the head winds likely to be encountered. No such service has as yet been actually started either here or abroad.

In England various airplane firms have ready machines carrying from 10 to 40 passengers; the French Farman

[1]Chief engineer, Glenn L. Martin Co., Cleveland, Ohio.

carrying 12 persons and the big Caudron company are only waiting for military questions to be settled before opening up regular service between London and Paris and other European cities. England has big projects along these lines throughout her colonial possessions and seems imbued with the determination to realize them. In Italy Caproni is building larger passenger planes than anyone, which it is said will be operated from the northern to the southern part of that country and even across the Mediterranean to the African possessions.

Other enthusiasts believe that the safest course to pursue in breaking into the transportation of passengers is through the use of the taxi system. To illustrate this I may state that the Curtiss Aeroplane Co. intends to maintain a fleet of fast machines at a flying field near New York City, always in readiness with expert pilots in attendance to take anyone with the necessary confidence and money to any part of the United States. Our Air Service has for some time been using planes for a similar service. In Washington several machines and some of the best pilots in the service are ready at any time to carry high officers or officials on a joy ride or a quick official trip to other cities within a radius of 400 miles.

At Atlantic City companies are planning to handle the tourist trade. That they will meet with success in joy-riding pleasure seekers next summer seems dependent only on their intelligent use of the best materials and personnel.

Airplanes as Mail Carriers

Passing to the second commercial use of airplanes, mail carrying, we enter a field where the element of danger is not of so much importance. It is not to be neglected any more than in passenger carrying, but the possibilities of crashes do not limit the initial business.

Under the heading of mail carrying I will group several functions:

(1) Regular mail transportation
  (*a*) By the government
  (*b*) For the government
(2) Fast dispatch service
(3) Financial service

In regard to the carrying of mail by plane, everyone is acquainted with the fact that the Post Office Department has had a service in operation for the past year between New York City and Washington. It has operated this with its own personnel and material, and made a remarkable record on this run for efficient and continuous service. The amount of mail carried has, of course, been small as the service is only a beginning. About 160 lb. of mail is carried every day from each city, the pilots flying in all sorts of hazardous weather. Rain and storms fail to frighten them, and the instances of failures have been very few. The Chicago-New York City route was, as you know, unsuccessful in the first trials, but this was due mainly to faulty machines for this long haul, ignorance on the part of the pilots of the country traversed and a rather hasty start without proper organization and equipment. Next spring this run will again be instituted, and judging from the preparations being made and the machines that will then be available it should be as successful as the New York City-Washington run.

Whether the Post Office Department will contract with airplane transportation companies for carrying mail in other localities will depend to a great extent, I judge, on the record of performance actually accomplished in operating their lines for some other uses. It is not inconceivable that a company which had been regularly and successfully carrying passengers on a certain route would be able to secure contracts to carry some government mail along with the regular load.

Under the second function of mail-carrying types of planes comes independent carriage of special commercial dispatches. A service could be maintained with fast planes, flying both night and day, that would bid fair to outrival the night telegram service between cities over 300 miles apart. It would be as quick at probably lower charges and have the great advantage of accurate transmittal and the possibility of conveying information other than that written.

Machines engaged in this work could also handle the third class of mail-machine operation. Where the saving of a few hours in the time of transmittal of a draft on a bank in one town, to be deposited in the other, may mean the saving of a day's interest, fast airplane service would certainly be an advantage.

General Express Transportation

If we now take up the third peace-time use of the heavier-than-air machine, general express transportation, we enter a field which at first glance does not appear to offer much encouragement to the airplane as a carrier. Express and fast freight service throughout developed parts of the world is generally good and, of course, much cheaper than similar service by wing. One the other hand, as in carrying passengers, the future promises a class of people to whom the greater speed is a worthy consideration; so in the transportation of merchandise we will find classes of goods which can bear the extra cost of moving in exchange for the time saved. This may prove particularly true in conveying goods from small towns with indifferent rail service to the large centers. Among the articles which can bear the extra tariff are:

(1) Perishable goods
(2) Replacement parts for damaged machinery
(3) Medical and surgical materials
(4) Motion picture films
(5) Newspapers
(6) Luxury articles

Taking up the question of perishable goods that can bear the expense of airplane travel, we may list such things as high-grade certified infants' milk, rare and out of season fruits, vegetables and flowers. The milk for New York City is supplied largely from upstate dairies not having the fastest of rail service. With a preliminary cooling at the dairy this milk could be carried quickly and deposited still cold in the city. Where the breakage of intricate machine parts threatens the tying up of a plant, the aerial express line should find an opportunity to be of value. Shortages in factories working on a production basis that could ill afford an interruption could be made up from stock in a distant town in the minimum time possible through the air. Occasions arise in epidemics or catastrophes where the shortage of medical and surgical materials, personnel and food becomes serious. With airplanes such supplies could be rushed in the fastest way. Motion picture films could not only be distributed in the shortest time by airplanes, and thus cut down exchange and idle time, but the service would add to the advertising campaign of film companies. News grows stale quickly and small-town papers do not always satisfy the residents of such communities. The faster distribution would increase the out-of-town sales of the daily papers of our large cities and widen the range of their circulation. Articles of luxury which bring high prices in proportion to their weight could in many cases

have quicker distribution profitably. Advertisement would enter here to a greater extent than in any other class of service possible. Confectioners and florists in the large cities, enjoying a wide reputation and a high-class trade, could broaden the field of their patronage considerably.

Aerial Transportation of Mineral Ores

Mineral ore, while appearing to be a difficult cargo for seemingly flimsy aircraft to carry, is, in certain localities and in certain grades of ore, a practical load for airplanes. Where mines producing rich ore are located in inaccessible country not tapped by railroads or highways, barring exceptions where the character of the terrain precludes the possibility of landing fields or where altitudes are excessive, an aerial transportation system could be installed without the necessity for heavy investments in roadbeds and grading and could be operated at costs that would not be excessive. If the mine be a small one, removed from the possibility of surface service, the airplane can take out the ore and when the workings are barren leave no great amount of useless investment on the location. In addition to carrying the ore out, labor, equipment and supplies can be brought back on the return trip. Where speed in the operation of a newly found mine and in the marketing of its ore is an advantage, because of high market prices, an aerial system could be put into operation much faster than any surface system and would be delivering the ore months before the road or grading work could be finished.

The transportation of the ore from the mines to the nearest railroad might not be found to be the limit of this service, for at times and in certain undeveloped localities it might pay to carry the load farther to a district of better rail service. The distance of handling might today be limited to 300 or 400 miles because of the poor economy of carrying too much fuel, but there is reason to believe that with great load capacity and machines developed for this class of service, this range could be increased without too much loss in economy to 500 miles. To obviate the necessity of landing with a great load of ore, the machines could fly low over the receiving yard and drop their burden from the air. Where the haul was short, several round trips from the mine to the depot might be made with no landings at the latter, and time and the wear-and-tear incident to landing could thus be saved.

Aerial Photography and Map Making

One of the uses of aircraft that the war has done the most to develop to its present high state of accuracy is aerial photography and its application to the making of mosaic maps. Developed from the necessity of gaining accurate information as to the location and nature of enemy gun emplacements, fortifications and supply lines, the science of aerial photography has become such an exact one that not only can it be used to get true topographic maps, but it can be applied in the making or checking of maps and mapping observations. The bulk of this work,, and all interested in the furthering of flying throughout the country are hoping that much of it will be done, will probably be directed by the Government through its military or civilian personnel. It is not inconceivable, however, that companies engaged in the publishing of maps of the various parts of the country, such as Rand, McNally & Co., could find a market for better maps based on aerial photographs.

Owners of great ranches and plantations might find it of value to have the added insight of their possessions and the correlation of their various sections that would be afforded by a complete mosaic map. Advertising literature and descriptive maps of cities, resorts and real estate developments made by the aid of actual aerial photographs would undoubtedly possess enough value to warrant the expenditure necessary to compile them. In surveying undeveloped country for laying new railroad lines through it, the airplane would not only be a valuable adjunct in transporting the surveying parties and supplying them with necessities, but would aid in the making of their contour maps.

Other Miscellaneous Uses

Among the miscellaneous uses that we may hope to put airplanes to, come those of supervision and exploration. While in many of its aspects this work would dovetail with the photography previously outlined, in other ways it presents new fields. Consideration is being given today by the Government to the patroling of the great National Forest reserves by airplanes driven by or carrying an expert forest ranger. A greater check on forest fires could be exerted by this means and in that way much natural wealth conserved. More ground could be covered with smaller personnel, and reports of fires by wireless from the air to a central receiving station would expedite the rushing of fighting crews to the scene of the impending catastrophe.

The inspection and supervision of large properties is made more efficient and rapid by the employment of an airplane by the manager. It is reported that J. P. Morgan has bought a plane and engaged a pilot to aid the manager of some of his large wheat lands in keeping in touch with his work. Policing operations, both state and municipal, could be aided by airplane squads. State constabulary could throw a force of men into an isolated town where a strike or riot impended, by the use of large fast machines kept at central flying grounds. In the exploration of undeveloped country for following waterways or determining suitable waterpower developments, airplanes would provide vision and perspective to the pioneers.

Use of Airplanes for Sport

Among the last and what has appealed to so many as the first and best use to make of our present aircraft is the sporting development. Undeniably there is a field here, and had the war not intervened it would be farther advanced. For customers the producers of sporting types of airplane will surely have many of the returned and discharged military aviators. Most of them would probably enjoy the possession and use of a fast, able little craft, but unfortunately an airplane will always be more expensive than a motor car and hence few but the wealthy will be able to indulge their fancy.

One of the first obstacles to pleasure flying is the fact that suitable flying fields are not numerous or located in respect to each other in such a way as to make possible an ordinary jaunt of an afternoon. Flying in the vicinity of a field soon becomes tiresome. One way out of this difficulty is through the use of machines of the flying-boat type. Coastal waters, inland lakes and rivers provide ample landing room for sportsmen. Sport flying will no doubt increase in popularity in spite of its cost and probably be fostered by the Government. The enlargement of the landing facilities provided by the mail routes and commercial lines will assist. That it will ever approach the magnitude and popularity of motoring seems improbable; skill in flying is not possible of attainment by everyone; the hazards of flying can be combatted only by the

employment of elaborate precautions beyond the means of individual fliers.

Changes in Present Equipment

Having covered in general the uses of aircraft, we approach now the subject of the initial developments that are necessary before entering the field of commercial endeavor. These in the order of their importance are:

(1) Engines
(2) Airplanes
(3) Means of navigation
(4) Landing grounds
(5) Legal questions

As I expect to cover the future developments later, I will confine myself here to a summary of what changes, if any, we must make in our present equipment and methods.

Our best engines at present, as exemplified by the Liberty Twelve, seem to give promise, if properly handled and not overtaxed in power or length of service without overhauling, of giving satisfaction in regular service.

Our airplanes, of course, need considerable reworking to fit them for carrying passengers or inert cargoes, except possibly in the case of smaller machines used for special service. Some of our planes, built to give the ultimate in performance from a military standpoint, possess unpleasant features when applied to peace-time uses. These planes will be worthless as far as everyday use is concerned. Others will require only a changing of interior arrangements. Bomb compartments will be replaced by comfortably appointed cabins or conveniently arranged cargo holds. Accessibility and ease of replacement of wearing parts will be given prime consideration in redesigning these machines.

Our navigation means probably call for the most immediate developments. Air compasses now in use are not thoroughly satisfactory at all times and in all weather. Radio direction-finders have been developed and seem to promise a more accurate and dependable method of keeping a true course in flying across country above the clouds or in a rain or fog. Better maps are necessary at once. Present-day maps are usually lacking in true accentuation of natural landmarks such as rivers and mountains. Confusion is caused by the omission of some marks and the inclusion of others when perhaps both look to be of the same magnitude when observed from an altitude of 10,000 ft. or more. Cities flown over should be marked in some way to be readily recognizable by night or day.

Means of signaling the location of a field are necessary in a fog. Since most fogs are close to the earth, captive balloons riding above the fog in daytime, or star lights shot above the fog at night, will make it possible for the aviator to find his field. Proper and adequate means of lighting fields for night flying are advisable, since in some kinds of service this will present advantages over day flying.

Radio lighthouses along established routes sending out distinctive signals at regular intervals will aid the pilot in checking his position, which may be rendered uncertain by unknown wind conditions and loss of visability of the ground. Landing fields should be provided at reasonable intervals along the course of aerial routes. An endeavor should be made to locate suitable fields as near to town as possible in all cities contemplating airplane service, as a field distant from the center of a town tends to offset the time-saving of aerial travel. The shorter the run the more will be the magnitude of the disadvantage.

Serious contemplation should be given by the proper representative bodies of the State and the Federal Governments to the legal aspect of aerial transportation. Uniform laws governing the behavior of machines in the air and when alighting are needed, as well as inspection regulations to safeguard the public and eliminate ignorant and foolhardy operators. Proper instruction and examination of pilots are necessary; while the examination should not be so exacting at this time as to be unjust, it should be and can be thorough enough to safeguard against unsuitable and incapable operators.

Future Developments in Airplanes

It seems safe to assume that the uses of aircraft will expand rather than contract. This would indicate that we shall always have as many different sizes of machine and engine as now. Small single-engine planes will continue to attract sportsmen, will be used in special service and even in mail or passenger lines between small towns. Multiple-engine machines, however, possessing, as they do today, the added safety of being able to continue flight when one engine stops, seem certain to come more into use for all regular systems requiring the maximum of safety and dependence. Even though engines develop considerably in reliability, as they must and will, this type of airplane seems bound to predominate from other considerations. The size of the multi-engine machine will therefore probably vary more than at present. Starting with small two-passenger twin-engine airplanes, we shall probably have two, three, four and five-engine planes with horsepowers up to 5000 and useful loads up to 20 tons, operating in different services in the near future.

As to the speeds that we may expect the machines of the future to attain, it appears that while more efficient machines and engines will undoubtedly increase the maximum possible, many types will be slow. Where a service is operated over country not possessing fast surface transportation, or over broken country and large bodies of water, the slower plane, say that having a maximum speed of about 80 m.p.h., will be the most economical. The attainment of higher speeds will always mean the lowering of the useful load carried. Where there is good rail service, or other conditions call for the maximum speed, we may expect to find planes in operation making with their full load anywhere from 150 to 200 m.p.h. Speed does not mean less dependence or safety but more often surer and safer service. It does, however, except in certain instances, spell higher costs per pound of load carried.

The tendency in engines, as far as their size is concerned, seems still to be toward greater power. What the limit will be is hard to predict, since it is restrained somewhat by developments in other directions. Unless radical changes in the methods now used in the making of air propellers occur, it does not seem that units larger than 1000 hp. will be practical. Two or more propellers driven from one powerplant by shafting or other means may, however, make it possible to double or treble this figure, lacking any developments in air screw construction.

As to new developments in airplane design, aside from larger or faster machines, it is difficult to see that this will follow any new or startling lines. The problem of descending and arising vertically with heavier-than-air craft, while probably not impossible of solution, seems to present insuperable difficulties. Very likely compromises will be effected which will permit airplanes to land in more restricted fields and in terrain of a rougher char-

acter than is now advisable. Lifting screws, air brakes, variable camber, variable area and better landing gears may be used in the solution of this problem.

Refinements of structures by more careful design or employment of better materials will undoubtedly continue and will, by decrease of weight and head resistance, give greater speed ranges or greater load capacities.

Developments in engines seem to point toward the maintenance of power with increase in altitude and the consequent increase of speed and miles per gallon of fuel. Some success along this line has been attained already, and practical solutions appear to be forthcoming soon. More reliability in engines and the possibility of longer running without overhauling are of such advantage in commercial work that efforts will surely be bent in this direction. Better fuel economy will be sought not only from the fact that costs will be cut in this way but because weight will be saved by the reduction in the amount of fuel carried and the space gained will be available for more cargo or more comfort for the passengers. The three main developments in the engines then would seem to point to a higher weight per brake horsepower at sea level, but, of course, the maintenance of power at great altitudes and the lowering of the fuel consumption should offset this and perhaps eventually put us ahead of the present low-weight engine unit.

In the development of accessories and safeguards the field is broad and offers many opportunities. Automatic controls for the relief of the pilot seem certain of early attainment. Safeguards against fire and leakage from fuel tanks are well developed now, although not always applied. Improvement in both as to effectiveness and weight can be expected.

Muffling of engines, heating and ventilating of the cabins and housing-in of operators without restricting their vision will all come shortly and add to the efficiency of the pilot by reason of the increased comfort and freedom.

More durable materials for the covering of wings and bodies, protective coatings and the like will lower the present high rate of deterioration.

Service Cost Data

No doubt you have all at one time or another thought that you might like to take a trip in a passenger-carrying machine. You have no doubt wondered what the initial costs would be and what the rate per passenger-mile can be expected to be in the near future. With this thought in mind I have prepared the following brief cost calculations on a problematic service between Cleveland and Detroit. The costs include all operating and overhead expenses of a complete operating company. For this service I have assumed the use of one of the Glenn Martin Co.'s twin-Liberty 10-passenger planes equipped with pontoons for water landing. I have done this rather than use the land machine as in both Cleveland and Detroit suitable landing fields are too far from the center of town. Also, with a water machine no hesitation would be felt in taking a straight course from the one town to the other. If a land machine were used, prudence would dictate the following of the shoreline, with the increased distance thus made necessary, combating the time saving of the service. It should be understood, however, that this particular service is not the best example as to economy or locational advantage. Moreover, costs over the water will be higher than over land because of the poorer efficiency of water machines. That the estimates shown can be bettered for more advantageous service is possible of proof.

Condition of Flight

The distance is assumed to be 100 miles.

The high speed of the plane full out will be 105 m.p.h.

Regular flying will always be conducted at a reduced speed of the machine and the engines. This speed will average about 95 m.p.h. when each engine is delivering about 310 hp.

Schedule flying time will be based on this throttled speed, less 15 m.p.h. Scheduled speed will then be 80 m.p.h. and schedule time for the trip 1¼ hr. Schedules can be maintained against head winds up to 25 m.p.h., by running full out. As winds above this speed are occasional and usually accompanied by weather rendering flying inadvisable, schedule time should be maintained on over 90 per cent of the flying days.

In figuring the costs of operation and the depreciation of the machines and engines, this schedule time of 1¼ hr. per trip will be used, although the majority of runs will be made in less time than this. This will provide a factor of safety and cover idling of machines on the water.

We will assume that flights will be made 270 days out of the year, or about 75 per cent of the time. Further, we will consider that our average load will be eight people, or 80 per cent of the maximum.

The gasoline consumption will run 26 gal. per hr. per engine or a total consumption per machine of 52 gal. per hr. The total oil consumption should not exceed 2 gal. per hr.

Service

Assuming that the amount of traffic will permit the operation of two machines, each making six trips a day, three machines a year will enable this service to be maintained, as this would allow each machine a yearly flying life of 100 days, with 90 days for repair out of the 270 flying days in the year. We will assume that the total life of the machine is 1350 flying hours, and that to keep it in the air this time 15 per cent of the original cost is expended in replacement parts. Labor and material for fabricating other parts will be figured also.

We will assume that to keep each machine in the air 1350 hr. two sets of engines will be used and junked. The total running life of each engine would then be 675 hr. We will assume that in the life of each engine it is completely overhauled six times and that at each overhauling replacement parts equal in value to 10 per cent of its cost are used in addition to other labor and material for repairs.

Time Schedule

	Leave Cleveland	Arrive Detroit	Leave Detroit	Arrive Cleveland
Machine No. 1	7.00a.m.	1 8.15a.m.	2 7.00a.m.	2 8.15a.m.
Pilot	A	A	B	B
Machine No. 2	9.00a.m.	2 10.15a.m.	1 9.00a.m.	1 10.15a.m.
Pilot	B	B	A	A
Machine No. 1	11.00a.m.	1 12.15p.m.	2 11.00a.m.	2 12.15p.m.
Pilot	A	A	B	B
Machine No. 2	1.00p.m.	2 2.15p.m.	1 1.00p.m.	1 2.15p.m.
Pilot	C	C	D	D
Machine No. 1	3.00p.m.	1 4.15p.m.	2 3.00p.m.	2 4.15p.m.
Pilot	D	D	C	C
Machine No. 2	5.00p.m.	2 6.15p.m.	1 5.00p.m.	1 6.15p.m.
Pilot	C	C	D	D

It is seen then that four pilots are operating every day, each making three flights totaling 3¾ hr. in the air. Six pilots will be required to give the proper relief and reserve.

CAPITAL INVESTED AND EXPENSES

Property and Equipment Investment		
Docks, hangars and repair shops	$60,000	
Machine tool and hangar equipment	35,000	
Office equipment	4,000	
Gasoline tank equipment	3,000	
Total Property Investment		$102,000
Transportation Equipment per Year		
3 Airplanes, without engines, @$40,000	$120,000	
12 Engines @ $4,000	48,000	
Airplane spare parts (15 per cent of value of planes)	18,000	
Engine spare parts (60 per cent of value of engines)	26,800	
Material	10,000	
Total Annual Equipment Investment		222,800
Direct Operating Cost per Year		
Gasoline: 210,600 gal. @ 20c	$42,140	
Oil: 8,100 gal. @ 70c	5,670	
Total Annual Operating Cost		47,810
Annual Salaries for Personnel		
1 Chief pilot and general manager	$7,500	
6 Pilots @ $4,000	24,000	
6 Flying mechanics @ $2,500	15,000	
2 Shop superintendents @ $3,000	6,000	
1 Passenger and purchasing agent	4,000	
1 Auditor	3,600	
2 Ticket agents @ $1,300	2,600	
2 Draftsmen @ $2,000	4,000	
16 Field mechanics @ $1,560	24,960	
40 Shop mechanics @ $1,300	52,000	
2 Watchmen @ $1,300	2,600	
3 Stenographers @ $1,300	3,900	
Total Annual Payroll		150,160
Overhead		
Building and dock upkeep	$4,000	
Fire insurance on building and equipment	600	
Taxes	4,500	
Heat, light and power	3,500	
Office supplies	1,500	
Postage, telegraph and telephone	3,600	
Depreciation of buildings at 5 per cent	3,000	
Depreciation of machine tools and equipment at 10 per cent	3,500	
Depreciation of office equipment @ 10 per cent	400	
Depreciation of gasoline storage tanks @ 10 per cent	200	
Total Overhead		24,800
Cost of Operation per Year		
Transportation equipment	$222,800	
Materials	47,810	
Salaries	150,160	
Overhead	24,800	
Reserve for unforeseen expenses	20,000	
Total Annual Operating Expenses		465,570
Passengers carried per day (80 per cent of maximum)	96	
Passengers carried per year (80 per cent of maximum)	25,920	
Cost of trip per passenger	$18	
Cost per passenger mile	$0.18	
Gross receipts @ $22 per trip	$570,000	
Total profit	$104,430	
Investment Required		
Transportation equipment	$222,800	
Property and equipment	102,000	
Working capital required	25,000	
Total Investment		349,800
Percentage of profit on investment	30	

Assuming larger and faster land machines working up to the limit of their capacity, it can be shown that passengers can be carried at a good profit as low as 10 cents per passenger-mile. The fuel consumption mentioned is a little high because the engines are throttled and the Liberty burns 33 gal. per hr. full out, developing 400 hp. Throttling down to 310 hp., the engine speed is approximately 1600 r.p.m. We have no accurate results on gasoline consumption at that speed, but I know that going to Washington we burned a little more than 26 gal. per hr. per engine with the engines running about 1600 r.p.m. I think that consumption could be reduced.

The Discussion

QUESTION:—Have any comparative costs of aerial transportation by the dirigible and the airplane been compiled?

MR. DOUGLAS:—The British Government has a very complete record which was made at the close of the war. The data seem to point out that the cost of transportation will be considerably lower on long trips by the dirigible than by the airplane. I have much faith in the airship as a carrier and particularly on long journeys. It seems that almost everyone believes that up to 500 miles the airplane will get the business. Over that the dirigible will be used. Where the runs are too short for the dirigible, the overhead and large landing fields make the service a poor one, but for the longer distances it is a very economical means of transportation and far ahead of the airplane.

QUESTION:—At what altitude do you anticipate making the trips mentioned?

MR. DOUGLAS:—Usually from 4000 to 6000 ft. There would be no advantage in flying any higher, and flying over water there is a chance to land readily.

QUESTION:—Is it not true that the higher you fly the better the fuel economy?

MR. DOUGLAS:—It has been shown that this is true. Some time ago a test was run with a DH-4. I think the mileage per gallon was 6 at 7000 and 7 at 15,000 ft.

QUESTION:—Is it not a matter of air resistance?

MR. DOUGLAS:—Yes.

QUESTION:—What progress is being made in the way of metal construction?

MR. DOUGLAS:—Two metal wings submitted for experiment had practically the same strength as the wood wings but weighed slightly more. It seems that it will be possible to make metal wings of the same weight and strength as wood. The English have been doing considerable work along that line. Apparently they get results which show that the metal will weigh less than the wood.

QUESTION:—What has been the main cause of failure of metal propellers?

MR. DOUGLAS:—I think the main cause is that many of those which have been built have been freaks. I think it is quite possible to make a steel propeller. The Westinghouse people have spent considerable money in making Bakelite propellers. They have stood up well and make a very good job.

QUESTION:—Are they reinforced?

MR. DOUGLAS:—Yes. They are heavier but do stand the weather. There is no shrinkage or anything of that sort.

QUESTION:—I understand that some aerial torpedos have been developed.

MR. DOUGLAS:—I believe Henry Ford brought out one which was successful and Mr. Kettering has done some

experimental work on the same problem at Dayton. I believe they have not finished this work. The Ford torpedo, I understood, flew successfully and was controlled from the ground. They sent it on a long flight and it showed great accuracy in maintaining its course. It is controlled by a predetermined setting or wires.

H. H. NEWSOM:—In 1906 I was in one of the large opera houses in London and an inventor had a little model there that had six engines on it; two pointed up, two down, one forward and one backward. With wireless he sent this model, probably 4 or 5 ft. across, up around the balcony, made it loop the loop and do all sorts of stunts, and several times when it was out over the audience he sprung the trap door from the stage and dropped paper bombs.

QUESTION:—How does the speed change with the altitude?

MR. DOUGLAS:—It drops as you get up. I think there was not much change near the ground—75 m.p.h. at 7000 ft. and 70 m.p.h. at 14,000 ft.

QUESTION:—What is the average life of an engine?

MR. DOUGLAS:—We do not usually run an engine more than 100 hr. without rebuilding, although some have gone 120 hr. We have no really good data on that; 100 hr. seems to be about what can be expected without an overhaul to be sure of the engine standing up.

ADDRESSES OF MEMBERS DESIRED

MAIL sent to the members listed below at the addresses given has been returned to the New York office of the Society. Members who can supply any information regarding the present location of these members or offer any suggestions as to where their correct addresses can be obtained will confer a favor upon the Society by communicating with the Secretary at the New York office.

In order that the membership list may be brought up to date before the next edition of the Membership Roster is issued, members are urged to send in any information which they may possess promptly. It is only by the cooperation of the entire membership that the mailing list can be kept in an accurate condition and the members receive THE JOURNAL and other communications promptly.

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The Labor Problem

By HARRY TIPPER[1] (*Member*) PENNSYLVANIA SECTION ADDRESS

WE are almost overwhelmed in industry to-day by the speed with which the labor problem has come upon us. We hardly know why we should so rapidly have passed from a state of apparent unity into a state of such disorder. We cannot see what is back of these very imperative demands of the labor leader or what is back of the political strife within the labor organization itself and we are unable to visualize the difficulties that industrial owners and managers are having in retaining even a tithe of the incentive or a tithe of the interest that formerly we supposed we had from our workers.

We have to go back a little to get at the beginning of the picture. About two centuries ago the socialistic idea of political government was born in somewhat indefinite shape in France. It crossed to England early in the nineteenth century and became very strongly embedded in the political creed of a large part of the population there. It transferred itself to Germany and reached Russia, changing its conditions with the character of the country it entered. A little more than a century ago the economic idea of trade unionism was born in the north of England, on the borders of Scotland. It carried itself all through the industrial population of Great Britain, into France, into Germany, to a very small degree into Russia, and was transferred to the United States, each time changing its complexion because of the character of the population.

The socialistic idea is the only political program which has developed without any serious change and which has grown and defined itself. I want to impress this upon you because the things that we are seeing today are the results of that constant organized development which has taken place only with those two general creeds.

For 75 or 80 years the trade unionism idea has been very virile. It is the only economic program which has consistently developed along orderly lines from the germ to the full-fledged idea of today without any particular change. This latter idea developed coincidentally with the factory system. It is not that labor troubles began then, but the trade union idea as a collective body of labor organized for its own protection began during the early part of the nineteenth century and its development to the point of a strike practically coincided with the transfer of the mill from hand labor to the use of steam. To the workers, the trade union represented protection in the way of friendly benefit among themselves, mutual advantage, mutual insurance, mutual death benefits and protection *against* the employer. I want to emphasize the word "against," because this is warfare we are talking about and always has been.

THE REASON FOR THE TRADE UNION

The trade union had ample reason for its existence. The history of manufacturing in Great Britain from the beginning of the nineteenth century to 1865, and in this country from the Civil War, for 20 years, is not a history of which any present-day owner or manager of an industry could be proud. In fact, the early history of Great Britain is an appalling record of extreme exploitation economically, just as extreme in its exploitation as any despot ever was politically. This is what sowed the seeds of suspicion and consolidated the creed of action that we are finding today in our industrial life. The disease is an old one. It has been working consistently and regularly and has been developing for nearly a century. It is not possible that we can, without study, cure it or find a solution. We must charge ourselves as industrial leaders, industrial managers and professional men with a great defect. We have not studied it. In the course of a search through the bibliography of production, of scientific management, of motion study and all such books, I have failed to find any volume which discusses the human side rationally or as anything but that which is secondary to the equipment. It is true that in individual cases here and there, in England, in this country and in the other industrial countries, the practice of a single manufacturer appears to have developed an orderly human organization; from a moral obligation, as in the case of Cadbury, Ltd., in Great Britain, or perhaps from a keener and more farsighted policy in a business sense, as in the case of Filene in the United States. We have in both countries perhaps 100 individual instances of manufacturers who have studied the human side in relation to their own factories. The present conditions are the logical outcome of the history of the case. We have not provided the worker with any other picture of industry than the one he has secured through his union organization. In fact, we have constantly deprived him of much that he had had in his work before industry became a manufacturing system.

When I was a boy in England I had the privilege of seeing hand labor pass away in the town where I was brought up. The hand cabinet maker had a big job because he did everything from choosing the wood to the final assembly of the work. We have gradually shrunk that man's job to almost nothing in 100 years, and we have not provided him with any other important mental or intellectual stimulus of a controlled or educative character. Our educational system provides no education in industry, industrial necessities or development; our teachers are not provided with any information concerning it; our business men take no interest in it. As a rule our colleges are not practical. They are without any intimate knowledge of the history, growth, character or efficiencies of the present industrial organization. Thus, in the ranks of the workers we have had on the one side the steady, persistent promulgation and development of the trade union and socialistic theories, while on the other there has been no education as to the character and necessities of present industrial and political organization to offset this, or at least none worth mentioning.

In this country the conditions are serious because our population is not homogeneous. In Great Britain they can do things that we cannot, because while they are sharply divided as to their political ideas, nevertheless they are a homogeneous people and there is a certain traditional background of political understanding and

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development that, for the moment, serves to erect a common basis from which the discussion can start. But we do not have this. We have millions of people whose history is one of fighting authority, who have never known authority except as an oppressive instrument and whose whole tradition for centuries has been that the only way to establish liberty is to fight for it. These people we have not educated to any other kind of authority, and yet we are amazed at what they do against authority at the present time.

I have a friend who is a Pole; he is a very great thinker. I made that remark to him the other day and he said, "You are right, Tipper. I have to remember that it is wise to compromise. My instinct is to fight because my forefathers have been fighting for generations and generations back." I know a labor leader in New York, a Russian from the borders of Poland, who told me that at six years of age he was sent out to watch so that he could notify his father and father's friends, who were in rebellion, when the authorities were coming. Such people have no idea of authority, discipline or liberty as we know it under a well-ordered government, and we are at present without any means of educating them. We have not studied, considered or thought of the subject. We must frankly admit that while labor was reasonable in price or plentiful, we did not care much where it came from or what happened to it.

This is the background against which we must consider the industrial organization of today. It must be concluded that an industrial organization is not efficient which will neglect the most important factor for production. The management must realize that orderly labor, whether brain or handwork, has the only real value, and that wealth is nothing but the surplus of past labor, at present invested in future production.

What is this change that has transpired? We know that years ago labor had an interest in its work, no matter what the work was. We know that human beings have a natural incentive for occupation. We know that it ought to be possible to cooperate decently to produce something, and that there must be fundamentals of organization which can be applied to these cases. It is apparent that the unions are not effective, nor are the manufacturers' groups any more so. Today the unions are losing their discipline because of their great size and power. So long as they were not powerful and were fighting against a larger power, they maintained discipline within their own ranks, but when they ceased to be the smaller and became the larger power the division in their own ranks appeared on the surface and their unity was shattered. This must always be true where an organization is built from a sense of demand and not from a sense of obligation, no matter whether concerning an employer group or a union.

In the course of the last five years I have checked up the action of both sides in nearly 3000 strikes in Great Britain and this country, for I have no brief for one side or the other; they are equally unjust, in my opinion. I have seen very few instances where the union would not break its contract if the advantage was sufficient, and I have seen just as few instances where the individual manufacturer would not similarly break away from his group. In fact, the great fear of any manufacturers' group when combined is that some firm will weaken, and the great fear of the labor union is that individuals will weaken. No national or international collective body can heal the industrial unit which is split up by opposing ideas when the only possible solution comes from a cooperative effort to produce the same thing. How, then, are we going to attack the problem? There is no present solution. This is true because the disease is too old and too deep-seated, but there are present possibilities of an improvement which will afford a basis for future solution. There is no question that men once affected with an idea until it begins to operate may move to their own destruction in spite of everything. This they have done time and time again in the history of the world, and we must improve the situation if we are going to avoid disorder and destruction in the course of this movement.

In this connection I want first to examine the industrial organization in two ways, one of which is the way mentioned in my paper; but before doing so I want to point out the functions of organization. In every human group organization there are two functions, the function of doing things and the function of agreeing upon the rules under which they shall be done. The first is the operating or executive function, and the second is the legislative and judicial function. In small organizations both of these functions can be operated by the same machinery of organization because the discussion does not need to be formal; it occurs continually in an informal way, the agreement is reached by such discussion, and the operation continues by the loyalty which is exercised through that same means. In regard to the operating or executive functions, great power lodged in an executive and prompt obedience to such power by subordinates are required. An executive must decide thoroughly and execute rapidly and continuously, which means one-man power, and there must be ready obedience to such power to get the execution in force and finish the operation. Legislative work does not require immediate operation; it requires rather full, free and frank discussion and a complete agreement, for, unless the rules under which men shall work are agreed upon, the work itself will suffer by this lack of agreement, and at some point the lack of agreement will divide the organization.

Because industry is a magnificent organization, it has survived many of its failures, but the reason for the trade union, and the manufacturers' group has to oppose that trade union, is because the individual organization offers no legislative possibilities and cannot provide any agreement with its workers. It can only promulgate to them, it cannot agree with them. With an organization of 10,000 men working in the same factory and spending the major portion of their waking hours there, with their individual likes and dislikes and disagreements, a legislative requirement almost as big as that of a city is created. Immense numbers of people are employed outside to legislate for these workers during their relaxation and entertainment hours; but there is no machinery to legislate for them in the real meaning and purpose of their lives. It is because of this that the union has grown to be a very inefficient and clumsy weapon, a substitute for a united industrial organization for fulfilling both functions in order and as they should be fulfilled.

An Incentive Necessary for Production

Secondly, every piece of work must carry its incentive within itself, and this incentive must be continually a somewhat larger mental necessity. I defy any man to stick continually to a piece of work that has no mental stretch in it, that does not offer some necessity for movement in the intellect, without either going crazy or becoming a Bolshevik. Yet we have continued for years, for a whole century, in fact, to decrease gradually the dimensions of a man's job. While we have increased his conveniences, his possibilities of ambition and his desires,

we have *decreased* his job because in the old days when a man had a trade he had it and not an infinitesimal portion of it. He had to study his trade and did not become a routine machine tender with four motions to make 500 times daily.

I went into a leading electrical equipment factory a while ago. I was standing by a white-haired man. His age rather interested me. He was punching plates, just pushing them into the machine and punching them. I asked, "What is that plate?" He replied, "That is P-X-111." I said, "You do not understand me. I asked, 'What is the plate?'" He said, "I have just told you." "My question was wrong, then," I continued. "What do they use it for?" He answered, "I do not know." I said, "How long have you been here?" He replied, "Twelve years."

Now, nobody can tell me that this man's incentive could possibly be in that job at the end of 12 years. Nor can anybody tell me that it was other than mentally demoralizing, because it was restricting the mentality. No man ever thinks very much unless he has to in his daily occupation, because the habit of thinking is a hard one to acquire, and this man was not developing. Yet this man had the vote and the political power to overturn the government tomorrow, and we have pushed his job down to such dimensions that he has no incentive for real thought.

I do not believe it is possible to get production under such conditions. Why was it that during the war we got such wonderful changes in production? We did not change the machinery very much. I did not hear that such a very large number of inventions on machinery came out during the war, or that they so changed the operations of industry. But here is a case in England, mentioned by Lord Leverhulme, of five units making 3000 pieces each day. They had to move the plant. They inaugurated a teamwork campaign with competition between the teams and gave such extra incentive in the way of money reward for that teamwork as it deserved. Then they added the patriotic incentive, and where a total of 15,000 pieces were made with five units, by moving over one unit the four remaining units still made that number. Next, by moving over one more unit the three units still made 15,000 pieces. Finally they were able to maintain production with only two units.

In this country, the incentive provided during the war by patriotic work and by extra monetary rewards increased with the same organization in a number of well-authenticated cases from 50, 75, 150 and even 200 per cent. An incentive to work is a production question. How shall we provide it? We must do this to secure efficiency. In the printers' strike in New York City we could have afforded to pay those men all they were asking and grant them shorter hours if we could have provided that production incentive, but failing in this we could not afford it, because we could not transfer the increased cost. That incentive is the principal necessity of production. Production is not a matter of machinery. It is about time that we abandoned this idea. Throw away the old bibliography that begins and ends with machinery. Production is a matter of humanity and of human understanding, with machinery fitted to human beings and not with human beings changed into machines.

Shifting Men to Increase Production

I have an interesting case indicating that the day of courageous experimenters has not yet gone. I suggested to a friend of mine recently in connection with this one-man, one-job proposition the idea of incentive and what could be done to capture it. I said that it is partly a matter of organization, of giving the man a chance for expression, partly a matter of partnership and partly a matter of the work. I said that I did not believe that 25 years hence we will consider this one-man, one-job proposition a scientific proposition at all. It may take 50 years, but we are going to get at it seriously and experiment with it and demand a change. Three or four weeks afterward he said to me, "I have been thinking about that matter and I had a very interesting illustration. We have in our mills a job of grinding chemicals on the pulverizing mill and the man has to change the pressure according to the sound of the mills. At one of our mills we had a man who was particularly sensitive to sound and who did this fairly well. We had no trouble for three years. One day I heard that the mill was out of business and that we would not get any more shipments from it for a year. I went out to see the man who was operating the mill. I had made up my mind that I could not stand that job myself, and I thought that the man was in the same box. I talked with him when I arrived and when at the point where I thought we understood each other I said, "Tom, why did you smash that mill?" He looked at me and seemed to wonder whether he ought to say anything or not, and then said, "I was not feeling good that morning, and I wanted the noise to stop." "Well," I said, "that's all right, Tom; I guess I agree with you; I would grow tired of it, too, once in a while, but I have arranged that you will take Bill over here from the packing room and train him to do your work just as well as you can, and you are going to take half time here and half in the packing room. The packing room is nice and clean, there is no noise in there, and any time in the morning that you do not feel like staying at the mill because you do not like the noise you go out into the packing room and let Bill come in here." The final result was that my friend said to me subsequently, "I have taken on about five other departments and switched them around. I have the men in the packing room doing all of the six different jobs there. I rotate them around the whole six, and we are getting 25 per cent more work. I suppose that I will not notice the real effect for a year or two yet."

Results Obtained in England

Such may not be the solution, but it suggests something. Mr. Beecroft told me that one man who began that method in one or two departments of an engine factory in Great Britain started a man to grinding crankshafts and fitting them to bearings. Next he had the same man make the bearings. He said their accuracy and speed were better, and the men were more contented. I do not know, but it seems to me very human that they should be.

Everything that the psychologists and the medical men say to us is absolutely against the extreme concentration of mental and physical activity upon a few motions. When training workers in the textile factories where women were working under the most cruel operating conditions, I have seen girls become hysterical and have to be taken out within the first six days of their training, who absolutely became sick on account of the very high tension caused by that constant necessity for repetition at a single given second. You know how they must relax to escape from it when they get out, and the intensity of their emotional relaxation outside is the necessary protection provided by nature to get them away from that intensity of concentration in their work. I believe this is not good production. I am sure it is not good

human production, and I believe it is making a race of men who are not capable politically of self-discipline, self-government and real sound judgment.

Need for Publicity and Education

Education is another point, publicity education. Business has been too secret. It was nobody's business what a manufacturer did or what he made or how he made it. Least of all was it the employes' business to know this, and yet the manufacturer now complains that the employe does not understand. Well, how in the world could he? Where can he get understanding? There is in the United States no school, no public school where he can get it, because nobody in industry has supported the schools. They do not know anything about it.

A manufacturer in a small town where he has been a power for 30 years was giving me his opinion of the character of the workmen he is now getting. I asked, "What is the public school system in your town?" He said, "I do not know." "Well," I continued, "what is the curriculum?" He answered, "I have never thought about it." "Do you know any one on the school board?" "No; I did know one of the police, a friend of mine, but most of them are politicians and I do not know anything about them." I said, "Did you ever run a night school in your place?" "No," he replied, "I thought about that this last year or two but I did not do it." I said, "Where can your fellows get the information? You never publish any statements about it. You never take the time to tell them about it, and they do not know whether your overhead is camouflaged or whether it means expense. They do not know what your stock is. They do not know whether you have printed pieces of paper and sell them for money or have an obligation on it. They do not know, and they have been born and brought up, from the time that they have been youngsters, with the tradition of the trade union idea which tells them that the manufacturer is logically and seriously unjust, and that they cannot trust him. There is just enough of record in the history of the thing so that they have the chapter and verse to continually remind them about it, and you have never done anything serious to combat this. It is true that you have established a few hospitals which the labor leader said came out of what ought to be wages. It is true that you have established a few playgrounds and activities of that kind, with the same comment from the labor union, and it is true that there have been established occasional night schools to train employes better for their work, but it is not true that attention has been paid to the manufacturers' necessity that the workers should know. They should know because they are in the majority and have the majority vote. Unless we are to have a government by the unintelligent and ignorant, which is the worst and most unjust government that could possibly threaten anybody, we must increase the intelligence, judgment and capacity of the skilled men who are working with their hands and the brain-workers, so that we can get a more coordinate understanding of the industrial problem.

There is not any question in my mind that production as a science is just beginning. We must gather together in industry; we must listen to what the medical men have said, and they have said some very pertinent things on the character of fatigue, on muscular movement, on the fatigue effect of continued rapid muscular movement, and on the mental system and its necessities. And we must think about the psychology of the problems because our production depends not upon the amount of brawn a man has or the capacity of a machine, but on the thinking that the man does in connection with his machine and his work. Our present and future problem is a human problem, the governing factor of production. You know enough about equations to realize that when the governing factor is left out the remainder of an equation might just as well be thrown away.

The Discussion

W. M. Newkirk:—I have attempted at times to get our superintendent to try shifting the men around, and I always met with the objection that they cannot get started at it, that they lose a part of their pay for two or three days or even for a few weeks before they get used to it, and they always fight the initial move. I know it to be a good thing if you can once get it started. I wonder if you can give us any pointers as to how to lubricate the start.

Mr. Tipper:—That is always the difficulty with new things. The inertia which has to be overcome is the hardest thing. The average man will not accept responsibility and we have to start it. Only a few experiments have been made in this direction; the lack of experiments in this direction is almost amazing, but in one or two cases it has been started by taking a particular problem that developed itself and operating on that problem. It obviously takes about fifty times the analysis to route men properly as it does to keep them still. It is comparatively a very easy thing to put a gang of machines together and then fit a gang of men to those machines, but to take a number of men and fit the machinery operation to them is an entirely different story, and I do not wonder that the men balk at it. If we have not studied human nature very particularly, except as every man knows it, of course, this is a hard job. It takes far more analysis and keener judgment. To avoid confusion and get the results of related work is a very difficult job. I do not think as much rotation is needed as would seem to be necessary to the man who has not studied it. Just take two or three matters which are closely related, that will provide variety of muscular and mental activity and utilize the results of previous work in its relation to the other work that a man gets. If a man can just see the results of his work he has gone quite a distance. The reason it was wise to put the man who had been grinding crankshafts at work on the bearings of the engine is because the results of his grinding came right out when he fitted them up. These results also fitted right back into his previous work, and with the three jobs it gave him more than nine times his former horizon and three times the change in his position, his mentality and his physical concentration.

But you will have a hard time in trying to put this over with anybody. A man will transfer his responsibility of thinking if he gets a chance.

It is the inertia against experimenting that is the hard job. None of these things is half as hard when you get down to it as appears on the surface. You look at the whole shop and say, "I cannot do that!" when if you would take two or three men that are a problem, work it out with them and get their help you would probably hit upon the practical scheme. I have no faith in this large national conclusion. It never got anywhere or never did anything in human affairs, and that is the reason why I have no faith in the industrial conference at Washington or the international labor conference. You cannot settle things for 1,000,000 people by one conference. You have to settle it with a few people here and there, and when you have a fair proportion of those problems solved your big questions are auto-

matically settled. If you start with one thing in a particular corner of the shop and settle it, by continuing this you have the shop running smoothly on a different plan before you know it. That is the only way that I can see to get it done.

C. A. MUSSELMAN:—Have you been up against this problem? You know that in the printing business there are a number of unions, including those in the composing room, bindery and press room. We have attempted some shifts but the unions object.

MR. TIPPER:—That is to be expected. The only point there is this, how well off are we at present? We are trying to evade an issue, because we do not know whether the frying pan is a little cooler than the fire. We are in the frying pan and have been in it for a number of years and the fire gets a little hotter right along. The question is, are we going to jump out into the fire or on the grate. We are afraid to try, we have temporized and temporized with this question and we have waited right along and never done anything about it.

The unions do not want a solution because they are not nearly so much interested in solving the problem as in maintaining the strength of their rights; neither is the manufacturers' group. I will guarantee that any salaried official would hate to see a solution of the labor union that did not come through his association. He is behind it in the virility and capacity of that group and cannot think of any solution outside of that and he is against anything that tends or appears to break up that organization. But how are we off today? The leader says, "Don't do it," and the men do it, at least a sufficient number to embarrass us. In the printers' strike in New York City we are in the position of the innocent bystander who got into the trouble. We have nothing to do with the case. Certain unions have refused to do what the central union has requested them to do. The same thing is true in Great Britain. I am watching these cases by reading the London papers every week. There is a standing agreement which the iron founders' unions and the manufacturers have had for a board of arbitration for 20 years, but three units decided to strike in the face of it. The longshoremen struck without their leaders. Fully 59 out of 60 strikes that occur at present are unauthorized and mostly unapproved. What is the use of considering the opinion of a union that cannot discipline itself? The only unit is the factory that the men are working in. You cannot split it and heal it by a national or international agreement. It cannot be done. You have to start the experiment in your own shop and take the troubles as they come, just as you have taken the present troubles as they came.

It is over two years since the I. W. W. started work at Toledo very strongly. Their organization there is almost as large as at Detroit. The strike at the Overland plant at Toledo had been due for six months. It was authorized six months before it touched Toledo. There was nothing which the Overland people could do to prevent that strike. The organization of that strike antedated the company profit-sharing by a great many months. That strike, like the organization of the steel strike, was going on for 6 or 8 months and some of it was 15 months in organizing.

It may be interesting for you to know that the radicals of all the Russian and Soviet societies in New York and the I. W. W. have 2500 paid lecturers today in the United States of every race that is important industrially as workers, and that they have 40,000 active workers in the city of New York, and they have closely organized and intertwined headquarters in every industrial city. If you are known at Fifteenth Street in New York City, you can get all the material to strike in any industrial city in the United States within a week after they have passed upon all the credentials.

I should like to add just one point to that while I think about it. I made the point in my speech, and I am afraid it has been overlooked, that you did not get the significance of it, the traditions of these people. You know yourself how strong your traditions are, how much stronger they are than your recent reasoning, that on the very slightest occasion your tradition governs your sentiments, your reasoning goes by the board. There are millions of people in the United States who have no traditions except that authority is something to be fought, and they are fighting that authority here just as they fought it at home, where they had good reason for that fighting. They have been fighting for centuries in one way or another the authorities who have been forced upon them. You cannot destroy that condition; you must expect it to operate in all the councils of labor in this country, with little attempt at Americanization and with a background which is so strong. I have just told you that in every race there are lecturers constantly inflaming that sentiment as a part of their present program. I have seen them inflame the racial sentiment with things that happened a long time ago.

RUSSELL HOOPES:—This subject has been very interesting. We are a small organization and keep very closely in touch with our men. Whenever troubles come up we try to solve them then and there. We try to do just as Mr. Tipper has said, get into human touch with them, but believe we have failed to a very large extent. I have recently read a book with which probably most of you are more familiar than I, "Man to Man," by John Leitch. It probably throws more light on what Mr. Tipper has been telling us than anything which I have picked up lately. Does it not shed considerable light on these problems?

MR. TIPPER:—Yes, John Leitch has done much valuable work. He has operated what perhaps is, up to the present, the most successful of the four different systems of providing legislative machinery in your own organization. There are four systems, the House and Senate plan that is John Leitch's, operated after the political plan of the United States, which makes it simple and easily understood; the joint council plan which was promulgated by John D. Rockefeller but which was in use in an indefinite way previous to that time; the joint committee plan which is a rather different plan from the joint council, and then the union plan which is the importation of the Whitley idea from Great Britain.

Mr. Leitch's plan is very successful. He is very sincere and thorough, wise enough not to take on more than he can do, and wise enough to see, and to oblige the manufacturer and the workers to see, that this can only be done because of an element of confidence and trust and that it will take some years to work it out. It is worth looking into. His book is good. It is one of the things which offers a possible and a probable basis for a solution of our troubles, at least a marked improvement in the labor situation, if we can take hold of it wisely, patiently and with a full understanding that we are not giving the benefactions but are actually trustees in the case; and provided—and I want to make this proviso because I have run up against it so much—provided it is properly promoted and understood when put into operation.

One of the largest companies in this country put in

such a plan. It spent nine months looking over these plans and deciding which it wanted before putting it into the shop, and then it put in the plan. It promoted the plan in an organization of over 20,000 employes, including about 15 races, with one notice in the different languages that looked as much like a summons to a police court as anything I have ever seen, and one booklet which began, "Nothing hereinafter provided abrogates the right of the company to discharge a man," and so on. The benefits were in the back of the book. It put the whole plan over in that promotion and it has, of course, had trouble as a result. There was no common basis of understanding, and if you pitch a lot of men into an organziation for which they have not been prepared you are going to have extreme demands, confusion and discussion and get nowhere and do nothing for a long time. You can avoid that if the thing is properly prepared and understood. On the other hand a company that I know spent two years with a plan somewhat similar to this of John Leitch. Its promotion was very effective because time and energy and brains were spent in preparing the plan.

MR. MUSSELMAN:—I should like to know if Mr. Tipper's investigation and experience have taught him that when the factories attempt to better the condition of the men it results in the focussing of the unions upon their efforts, bringing disaster rather than benefit.

MR. TIPPER:—There is no question that from time to time a change in the organization of a manufacturer's plant to furnish a better means of providing an organization has brought the unions down on it, but I want to point out the fact which still remains that there are plants in this country that have not had a strike in 10 or 20 years, not because of special machinery, but because of the character of the human contact within the plant. Plants which have been using some special organization for eight years have never had a strike, and others which started the organization not long before the war did not have a single strike in the whole war. The allegiance which you can create in a plant for the employer is stronger than any other allegiance, if you can get it, and you can stand any other disaster if you can get that. If you cannot get that, all other disasters are going to overtake you anyway, because after all what the workman wants is not the affair of his class in Chicago when he is a New York man. It is the settlement of his own individual and collective problems in his own establishment, his own kind of work, that he desires. It is true that there are a certain number of floaters, but in most establishments these become settled or solidified.

There is no more radical bunch than the members of the needle trade in the United States. They are very largely Eastern Europeans, but include a large number of Russians. In New York City they are the center of the radical societies. There is a large company in Cleveland that had the John Leitch plan in operation four years ago. It has this same class of labor very largely, which is the poorest one to do anything with, since it has a naturally rebellious background of fighting authority. During the war there was a strike in the needle trade at Cleveland. The committee of workers in the plant to which I refer wired Washington to leave them out of consideration altogether; they were not on strike, were quite satisfied and did not want to be included in any way. They wired twice, and then some of them were called in as witnesses before the War Labor Board. Then they sent a committee down to Washington to see the Secretary of Labor, to make sure that they would not be included in the decision which meant an increase of wages in the general trade.

MR. HOOPES:—This is a very interesting question, and in my own experience I have perhaps come as closely in contact with employes as anyone here. Hoopes Bros. & Darlington has been in business for over 50 years. The older generation, of which we have one still living, is active at 85 years of age. There has been a close contact all the time with the employes, and I can truthfully say that we have never had a general strike in the whole organization. We have had a strike in one or two departments that lasted probably a few hours, but as for a general strike or being out even half a day we have never known what it is. I attribute this largely to the personal touch we have had with our employes. I ought to qualify that by saying that the plant is located in a rural community of good old stock. We do not have to bother about foreign workers and we get a good class of labor. Both those things have produced good results.

G. WALKER GILMER, JR.:—What Mr. Tipper has said is bound to be of interest to everyone employing labor. I am a laborer myself because my firm employs me to labor. We have troubles which have never gone far enough to get into the strike stage, but we realize that we have not the efficiency which we had several years ago, and should have today. Just how we can get that interest of the employe is a question that is naturally concerning us, and we have from time to time discussed it. We have our foremen's meetings regularly to discuss just such questions and how they are going to be solved. Mr. Tipper says it is now a question of warfare. I do not believe that is right, and it is not exactly a period of unrest. It is rather one of misunderstanding. A few years ago the manufacturers did not understand each other; consequently each thought when the other fellow was going after his business pretty hard he was going to cut his throat. They got together and began to believe that each man is honest, and we are, and so is the laborer, I believe. Generally speaking I believe that the laborer is opposed to striking. The difficulty is that he has been listening to propaganda carrying out the old belief with which a great many of them came to this country feeling that it was up to them to fight somebody and they did not have anybody to fight but the employer, and they are doing that. They are not fighting altogether in an organized manner at the present time, which shows that there is a lack of understanding even in the union. There is really only one remedy that I know of and that is the counter propaganda of education. A great many firms are working on it at the present time. It is not new. It will take years for it to amount to anything, but I believe that we will get results. There is no disease that is widespread which has ever been cured in a short time. We have just learned that the Surgeon General of the Army has cured yellow fever. He has been working on it since 1897 or 1898. He started in Cuba, I think. Possibly he has cured it. We can cure the misunderstanding which exists in labor today if we can understand labor and make labor understand us.

I believe that it is possible by changing the men around from one position to another to educate them and interest them by the use of publicity or rather pamphlets and possibly pictures, showing the connection of their work with the work of the various departments and also with industry in general, showing the connection between my plant and some other man's plant. There is

much that can be done, but it has to be worked out slowly.

MR. TIPPER:—I just want to add one more point in conclusion, a thing brought up a little inferentially. Of course it is a misunderstanding, but that misunderstanding is war. Manufacturers said competition was cut-throat when it was not organized by friendliness, and there is no organization by friendliness between labor and capital today. Both sides are more concerned with strengthening their outposts than finding a solution, and that is the reason why, when they went down to Washington, they adopted the group vote in conference. They could not conciliate. Gompers could not conciliate because he had to strengthen his organization. That is a type of war; it may be the forerunner of a more serious type of war if it is not understood and measures taken to spread the understanding. That is what we have to do, and everything that I have said tonight has really been in a measure the spreading of understanding. We cannot do much spreading unless we understand something ourselves, and I want to recommend as my last thought that you take notice of the statement of a friend of mine who said. "There are a number of people who study but who do not think." That is the reason we accept the traditions of the past and study without questioning, because we take the textbook "as is" without thinking whether we agree with it or not. We want study on this, yes, but we want understanding which is the motive of study. If we get understanding we will move, but if we merely study and do not get understanding we will not move.

M. C. DITTMANN:—How can we expect the operator of a machine to see the possibility of his becoming readily proficient in handling a different type machine from the one he has been accustomed to handle for a long time, when we employers, who are supposed to have a much broader vision than the operator, have difficulty in reconciling the possibility of a man who has become trained in the operation of a certain type of machine being able to switch over to a somewhat different type of machine? I should think this would be particularly difficult if the operator was working on a bonus system of reward, whereby he was paid so much for each piece and on his regular machine was making a certain amount above his minimum wage. Would he not consider that if he was shifted over to another type of machine his wages would fall off, due to his inability to produce, for the time being, at the same rate as was possible on his regular machine? On the other hand, if in offering an incentive to him to change over to the other type of machine, we gave him the same average wage that he had been earning on his regular machine, how are we going to offer him the incentive to reach the point of efficiency, or better, on the new type that he had reached on his regular machine? When we carry him along at his average previous earnings he merely has to run along without exerting any particular effort, for he is guaranteed his previous average wage and why should he exert himself to produce more work when he is getting paid what he previously earned?

MR. TIPPER:—That is a very acute and practical question, and it can be answered in two ways: First, it is not likely that in 100 per cent of the cases, it will be necessary to change a man's job immediately. Nevertheless, that is not the answer to the question. The formal method of doing a thing, the decision of a plan, is usually the poorest method of starting it with human beings. It is like saying to a man, "I am going to shift your job today and next week I am going to talk it over with you." I have got to sell him that shift. If I say to him, "Bill, you are a good man. I think you have a little more capacity than just this job, and I have a little problem here. I wish you would shift yourself over to this particular proposition and see if you cannot straighten it out for me," I can capture his interest and get him working on the job. He does not know that there is any shift. He is merely helping me out. If it is valuable for him to change his job, it demonstrates itself to him and to me without any formal demand that he remove himself from this plant and go over there. There is a tremendous amount of inertia to overcome. We do not like to move until we reach a certain stage of responsibility. After that we move automatically, because that responsibility has bred the habit of movement in us, but before that we have great inertia; and, as your intellectual capacity decreases or the necessity for it decreases, your desire for movement decreases. When you do not use the muscles they become so weak that you cannot use them after a while. The same is true of your mentality. It is painful to bring it back into actual existence and usefulness, just as in the case of a sleeping limb it is painful to bring it back into usefulness. Some of the pain is going to occur, and I do not believe that in every case it will be possible to change the whole proposition, or any single job, as a formality; but I believe that you can find out much and discover the changes that are valuable if you will approach it not as a formal but rather as an informal proposition. I believe in never revolutionizing any organization. It is a painful process and it takes so much longer to get the balance; the pendulum is always swinging too far. You can only do it by evolutionary methods. To find out, you have to begin, and the best way is to begin informally with a problem as it comes up. If you do it that way, I think that you can get over much of the difficulty, although you are bound to have some.

MR. DITTMANN:—Assuming that you have 100 men operating a particular type of machine, had you considered taking each of these men as an individual case or do you believe that the record the first half dozen or so of these men make in this change of operation will be sufficiently convincing and enough of an incentive for the others to agree to change over to a different type of machine?

MR. TIPPER:—I think it is better not to start with too many men at first.

MR. DITTMANN:—I am assuming taking one at a time.

MR. TIPPER:—If you take one, two or three men and give them sufficient time so that they are finally efficient in two or three men's jobs, as a problem they will sell it much better than you, if it really answers the purpose and gives an added interest to the men, an incentive. By taking the problem of one or two this itself will bring you finally a demand on the part of others, and the more intelligent man will demand it first because he will see the value of it. I think that there is no other way to do it. I would not counsel anybody in any of these changes to proceed as though this thing was a formal plan. I do not know how it will work out in the next generation or two. I simply point out that we have stultified a man over what he was 100 years ago, and we cannot continue to do that without producing a nation of brutes before we get through. We must turn around and I do not think that it is wise to go too fast the other way. Otherwise we will get utter confusion and disorganization instead of an orderly progress of organization.

Aeronautics in the United States[1]

By Major-General George O. Squier, U. S. A.[2] (*Non-Member*) *Illustrated with* Drawings and Charts

In 1907 the main requirement before acceptance by the Government of a heavier-than-air flying machine was an endurance test in which the machine must remain continuously in the air for 1 hr. without landing.

More than 8600 fliers have been trained in the United States since its entry into the war. Monthly graduations from ground and flying schools are shown on Fig. 1. The gradually increasing deviation between the two curves on this chart is caused largely by failure of graduates of ground schools to develop into fliers.

There have been training fatalities in the United States, as in all other countries where training has been conducted on a large scale. However, when the fact is realized that our students have flown more than 880,000 hr., which is the equivalent to more than 66,000,000 miles, it will be seen that our training casualties have been astonishingly few. Statistics show that the United States has a lower percentage of fatalities than any other of the allied countries. The monthly average in the United States has been only one fatality for each 3200 hr. flown. Training fatalities by months are shown in Fig. 2, and in Fig. 3 are shown the analyzed causes of these fatalities. Two independent investigations made in connection with this paper have developed the fact that more than 90 per cent of training casualties are attributed to the aviator himself. Fig. 4 shows the actual distribution of our fliers overseas.

A comparison of the weight of the Liberty engine with some of the better known foreign airplane engines is shown in Fig. 5, and fuel consumption in Fig. 6. The basic data for Figs. 5 and 6 came from official communiques from abroad. In the case of the Liberty engine the results of more than thirty tests were averaged.

Machines Adopted for Production

On Nov. 11, 1918, there had been developed, tested and adopted by the Army four airplanes, on which production would have started early in the present calendar year. These were the Lepere or L. U. S. A. C-11 equipped with the Liberty engine, the U. S. De Haviland 9-A equipped with the Liberty engine, the Martin bomber equipped with two Liberty engines and the Loening two-seater fighter equipped with the 300-hp. Hispano-Suiza engine. The characteristics of these new airplanes are given in the accompanying table.

That intelligent comparisons may be made, the characteristics of the De Haviland 4 plane are included.

Plane	Lepere	De Haviland 9-A		Loening	Martin Bomber	De Haviland 4
Type	Two-seater fighter	Day bomber	Reconnaissance	Two-seater fighter	Night Bomber	
Engine	One Liberty	One Liberty	One Liberty	One 300-hp. Hispano	Two Libertys	
Weight empty, with water, lb.	2,468	2,815	2,815	1,130	5,862	2,391
Weight of fuel and oil, lb.	475	933	933	290	1,492	457
Weight of crew, lb.	360	360	360	360	540	360
Weight of guns, ammunition, etc., lb.	352	764	214	828	1,769	374
Gross weight, lb.	3,655	4,872	4,322	2,608	9,663	3,582
Weight per b.hp., lb.	10.15	13.50	12.00	8.70	13.40	8.95
Weight per sq. ft., lb.	9.33	9.50	8.40	12.10	9.00	7.12
Speed at ground, m.p.h.	136.00	121.50	126.20	143.50	113.30	124.70
Time to climb to 6500 ft., min.	6	11⅔	7½	5⅕	10¾	8

Linen, Dope and Oil

As it was impossible to produce the millions of yards of linen fabric required for airplane wing and body covering, a suitable cotton substitute was developed and manufactured in this country in quantities sufficient to meet the needs of both America and the Allies, and at a cost slightly more than half that of the linen fabric formerly used. This accomplishment, theretofore thought impossible, ranks among achievements of the first importance. The dope used on the fabric of airplanes presented many difficulties not only to us but to our Allies. This and other chemicals required were soon being produced in this country in quantities sufficient for their requirements as well as our own.

To meet the extensive demands for a high-grade lubricating oil, castor bean seeds were imported from India and about 108,000 acres planted in this country. Meanwhile, research work with mineral oils was carried on intensively, with the result that a lubricant was developed which proved satisfactory in practically every type of airplane engine except the rotary engine in which castor oil is still preferred.

Behind the production figures of Nov. 11 was mobilized in the United Sates an industrial army of about 350 firms and corporations employing more than 200,000 men and women. A huge imaginary conduit leading from the factories and assembly shops of America to the fighting front in France was in operation. At any given moment, the number of engines, planes and accessories distributed along the 3000 miles of this imaginary conduit were known accurately and organized in such a way that the flow throughout should be continuous, or that minimum congestion should occur at any point, be it

[1] From a paper presented at a meeting of the American Institute of Electrical Engineers.

[2] Chief signal officer, Washington.

factory door, railway train, embarkation depot, steamship or debarkation point in Europe.

In November, 1916, I had the honor of addressing the National Academy of Sciences at Boston and outlining some outstanding problems for research in connection with aeronautics. Such has been the activity in research in studying air problems that fully two-thirds of the subjects suggested at that time have now been satisfactorily solved and are in actual use in the art. The new profession of air engineering is vying with the older engineering branches.

Physical Conception of Air

Everyone knows, of course, that if there were no air there could be no life, but probably very few fully realize its immense importance in almost everything we do. In one condition it is invigorating and gives us a zest

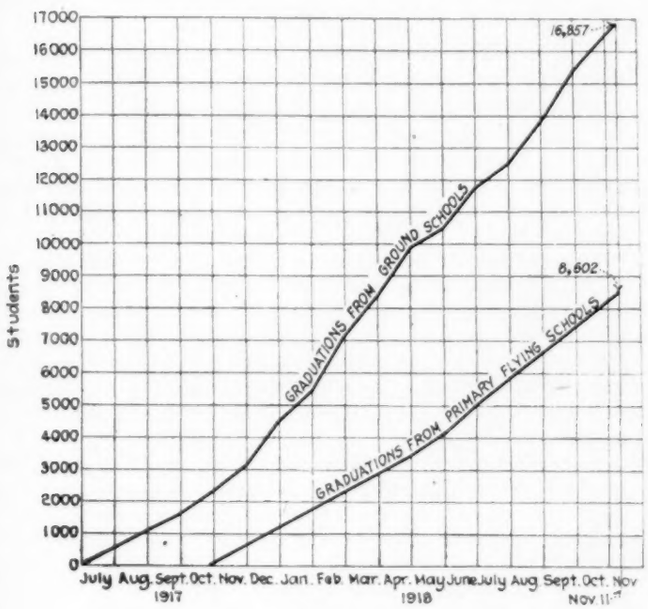

Fig. 1

for hard work whether mental or physical; in another it leaves us depressed and incapacitated for efficient labor. Numerous manufacturing processes are radically affected by the amount of moisture in the air and many others by its temperature. Power is transmitted by it; we communicate our thoughts to one another by vibrations of the air, and by its aid we have recently acquired our swiftest mode of travel. Obviously then, a knowledge of the composition, structure and physical properties of this universal medium is of such vital importance as to justify most painstaking study and research.

In the last few years, for instance, several elements, helium, argon, neon, krypton and xenon, have been found in the atmosphere that previously were unknown and even unsuspected, for they were not required by the Mendeléeff table of the elements as then understood. One of these, argon, amounts to nearly 1 part in 100 of the whole atmosphere, and yet through decade after decade of chemical investigations involving countless thousands of air analyses, it, and all its family of gases, remained undiscovered.

Recently, too, means have been found for drawing directly on the atmosphere for an inexhaustible supply of nitrogen compounds used in the production of power-

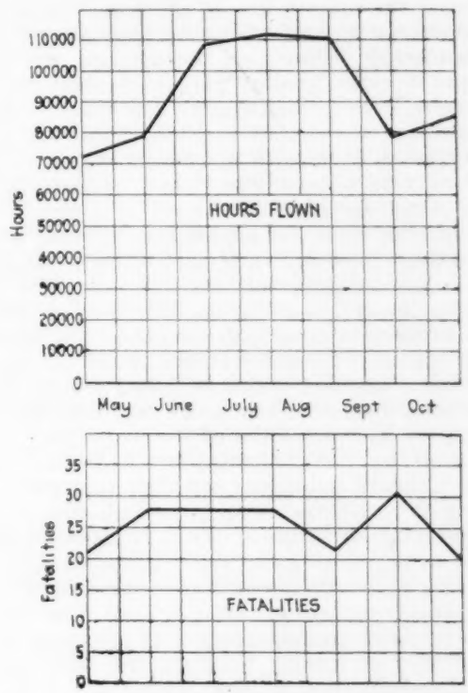

Fig. 2

ful explosives, fertilizers and many other things of industrial value.

The first 18 years of the present century have witnessed a wholly new and startling flood of physical knowledge which has resulted in profoundly modifying our conceptions of electricity and matter, as developed in the nineteenth century. These two great subjects have been brought together and are now recognized as one and the same subject.

What we called self-induction is now considered to be only inertia. Mass is supposed to be wholly electrical and a vector instead of a scalor quantity. The most fundamental of all physical constants, the electron, has been isolated and its charge measured. Electricity from whatever source is made up of these electrons and even metallic conduction consists of the actual projection of these granular units along the conductor.

A gas like the air, in the present view, is not a continuous medium, but is composed of many individual structures which preserve their identity and individu-

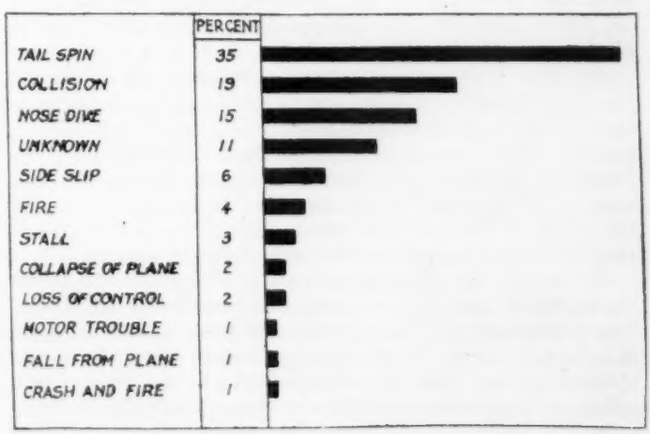

Fig. 3

ality during the normal life of the gas. These largest units are known as molecules, and they are all moving with considerable velocity on the average, the path of each being for the greater part a straight line until two approach near to each other. The forces that these two exert upon each other reach out into the medium which surrounds them both, creating a region of intense field at sufficient distance away from each so that their integrity is not disturbed.

When the two molecules approach each other, they are deflected off without collision, preventing a catastrophe much as a comet coming into the solar system is merely deflected by the action of the sun and does not fall into it unless it makes a direct hit, the chances of which are extremely small. The gas pressure of the air upon the walls of the containing vessel is merely the reaction of these deflected molecules that come into close proximity with the more fixed molecules of the container.

If we consider for a moment a cubic centimeter of air under standard conditions, we know that the number of the largest structures therein, the molecules, is a constant, and is about 2.705×10^{19}. It does not matter what kind of a gas we have, whether hydrogen, oxygen, nitrogen or compounds like methane, carbonic acid, etc.; the number of molecules remains fixed. In fact, we can probably determine the number of molecules in 1 c.c. of a gas more accurately than we can determine the number of inhabitants in New York City, in spite of the fact that the number is slightly more than twenty-seven billion billion.

By measuring the weight of the cubic centimeter of air and dividing this by the number of molecules contained therein, we obtain the weight of the largest structure composing the air, namely, the molecule. The structure of the molecule, while sufficiently enduring to remain together as a unit in the normal condition of the gas, yet is not strong enough to withstand forces that may be easily brought to bear upon it by chemical means to cause it to separate into still smaller units known as atoms. In the nitrogen and the oxygen of the air there are but two atoms making up each molecule, so that each structure in air can be divided into two parts only by any means at the disposal of the chemist.

The atoms, however, have been broken up into still smaller units, but it can be done only with great difficulty, comparatively speaking, and until recently the difficulty was so great that they earned the name atom, signifying that they could not be cut in two. They are far more enduring structures than the molecule.

The only two kinds of things that ever have been obtained thus far by the breaking up of the atoms of all kinds are the so-called positive ions and negative electrons, and these remain today as things which have never been broken up into smaller components. Whereas the negative electron has been isolated from gross matter, the positive charge has never been dissociated from matter. The present idea of physicists is that we have found an ultimate constituent of all gross matter. The mass of this negative electron has been measured, and the mass of the smallest atom, hydrogen, is 1845 times greater than that of the electron.

We regard the atom as consisting of a positive nucleus about which negative electrons are ceaselessly revolving. The dimensions of the negative and positive constituents of atoms, in comparison with the dimensions of the atoms themselves, are like the dimensions of the planets and asteroids in comparison with the size of the solar system.

In the light of the foregoing conception of a cubic centimeter of air, imagine if you can, what a complicated thing would be the result of an orchestra playing 100 instruments and 200 voices singing in chorus, accompanied by the orchestra. The cubic centimeter of atomic worlds, in this case, becomes subjected from without to a great number of superimposed frequencies representing each and all of the individual instruments, as well as the innumerable harmonics required to indicate the qualities of the human voices; yet our medium is sensitive enough to respond accurately to each and every one of these frequencies simultaneously, and synthetically adds them together and produces a resultant envelope curve of pressure which the marvels of the human ear are able to analyze and interpret into its elements. A medium which has such qualities as to be capable of acting and reacting in this delicate manner and at the same time when moved bodily with the velocity of a tornado can cut down trees and buildings as if by a giant steel knife is a medium the possibilities of which for future research we, at present, only dimly perceive.

Commercial Production of Helium

One of the greatest scientific achievements of the war from a technical standpoint was the production of helium in quantities for balloons. This gas is non-inflammable and has about 92 per cent of the buoyant effect of hydrogen. Its name is due to its having been discovered in the sun's atmosphere through a characteristic line in the solar spectrum, before its presence on the earth or any of its properties were known. It was first obtained in minute quantities by Ramsay in England some 20 years ago by heating certain radioactive minerals in which it occurs because it is a disintegration product of radium. Its pre-war scarcity may be appreciated from the fact that, up to two years ago, not more than 100 cu. ft. had ever been obtained, and the usual selling price was about $1,700 per cu. ft.

Notwithstanding so discouraging an outlook, someone in the British Admiralty had imagination enough to propose the large scale separation of helium from certain natural gases in Canada that contain about 0.33 per cent of it, and experiments were undertaken at the University of Toronto. Soon after the entry of the United States into the war, the Bureau of Mines, learning of the problem from a British confidential memorandum, persuaded the Signal Corps and the Bureau of Steam Engineering of the Navy to approve and finance jointly an experimental program on a large scale. Thanks partly to the unusually rich resources of supply in this country, and partly to the skill of the two commercial companies whose services were enlisted, and to the enthusiasm of the Bureau of Mines staff and of Mr. Carter of the Navy who for a time represented the Army as well in the project, such success was achieved that, at the cessation of hostilities, there was compressed and on the dock ready for floating 147,000 cu. ft. of nearly pure helium, and plants were under construction to give at least 50,000 cu. ft. a day at an estimated cost of not more than 10 cents per cu. ft.

The production of a balloon gas that assures safety from fire opens up a new era for the dirigible balloon. In November, 1917, a Zeppelin made the trip from Bulgaria to German East Africa with 25 tons of medicines and munitions, only to find that the German forces had already been dispersed, and returned safely to its base without landing. With a non-inflammable gas, not only comfortable and expeditious, but also safe, transcontinental and transatlantic travel in dirigibles will, it is believed, soon be commonplace.

Under the effective direction of Major W. R. Blair,

one of the most experienced aerologists of the United States, commissioned for the service from the Weather Bureau, about 20 upper-air stations were established in France and England and a forecast based on data furnished by these stations made regularly to the A. E. F. Twenty-eight stations manned by 150 men, all carefully picked at the start and well trained at College Station, have been established for furnishing local data as to either surface or upper-air conditions or both to the flying fields, artillery posts and proving grounds in this country. The largest of these stations is that at the Aberdeen Proving Ground, which is manned by twenty-two men and furnishes to the Bureau of Ordnance all necessary data for the determination of ballistic wind which, in view of the development of high-angle fire, has become altogether indispensable for the construction of range tables needed for obtaining accuracy in the work of the artillery.

Twenty-six meteorological stations were established at carefully selected points over the whole of the United States, which have been manned by trained observers who telegraph to Washington each day observations on wind velocities at all altitudes up to 35,000 ft. In one instance these observations have been carried to 65,000 ft. On the basis of these observations, a daily forecast of upper-air winds is now being issued. The use which such forecasts may serve, both in connection with the aviation mail service and ultimately with the transatlantic service, can be seen from the fact that above the level of 10,000 ft., 95 per cent of the winds in both the United States and Europe are from west to east and often attain velocities in excess of 100 m.p.h. On Nov. 6, 1918, at Chattanooga, Tenn., a velocity of 154 m.p.h. at an altitude of 28,000 ft. was observed. It is because of this easterly direction of these upper air currents that all of the long flights thus far made have been from west to east. The importance of a forecast of such currents for the purpose of long flights will be appreciated as soon as the foregoing facts are understood. An airplane capable of a velocity of 154 m.p.h. in still air would either remain stationary or travel at 308 m.p.h. depending on whether it was headed into or with a wind of the velocity of that observed at Chattanooga.

All of the aerological work so far mentioned has been done with the aid of theodolites especially designed by Major W. R. Blair for this service. Sixty of these have been built for the work in this country and twenty shipped abroad.

The problem of exploring the upper-air currents over the Atlantic was at first thought insoluble on account of the absence of fixed bases, but the Meterological Service has developed propaganda balloons which already have flown at an average altitude of 18,000 ft. from Omaha to New Jersey, a distance of more than 1000 miles. The success of the project has now made possible the mapping of the upper-air highways across the Atlantic; for arrangements are being made to send up from both coastal stations and from transatlantic steamers, these long-range balloons designed for from 2000 to 3000-mile flights and adjusted to maintain a constant altitude and to drop in Western Europe their records of average winds in these heretofore unchartable regions. The importance of this work for the future of aviation needs no emphasis.

Physiological Study of the Flier

Until a year and a half ago, interest centered in the development of aircraft and not in the flier. There was little regard for the special fitness of the man on the day and hour he drove his machine. This was true, not only in the United States, but also in the allied countries. The pilot was not selected because of any peculiar fitness for flying. It was simply a question of whether or not he had the nerve.

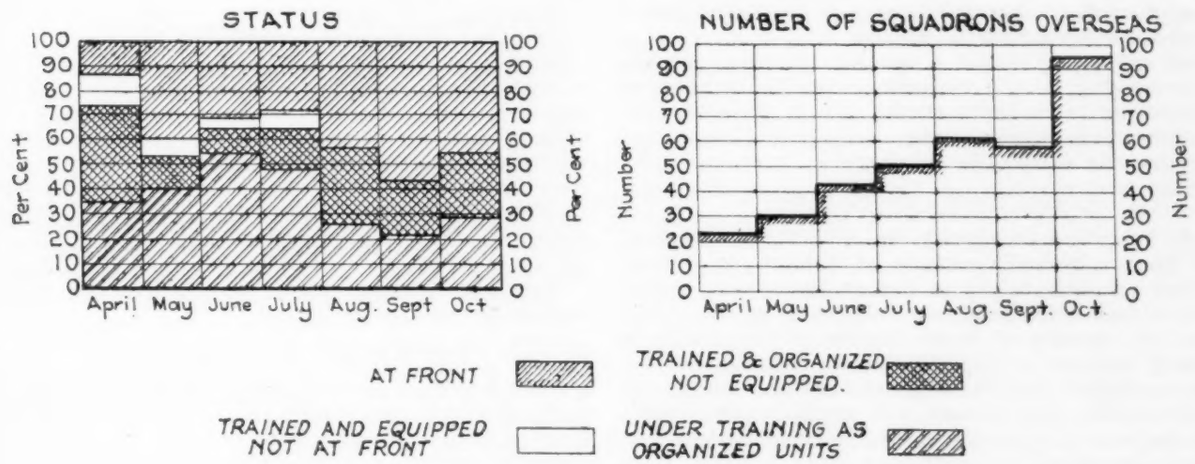

Fig. 4

But, about the time the United States entered the war, it became clear that the science of physiology could be applied with advantage to the selection, classification and maintenance of the aviator. Each of the countries in the war now has a fully established air medical service as an integral part of the air forces. In the British Army there is a separate air medical service with a Surgeon General of Aeronautics. In the American Army this work has been handled effectively by a division of the Surgeon General's office assigned as part of the Air Service.

The early view that any one who "had the nerve" could fly caused enormous avoidable wastage of life and material. The lesson learned from bitter experience was that it is essential to obtain fliers who are especially fitted for particular work and to keep them in condition to perform their duties at all times.

Nature never intended man to fly in the same sense

that she did not intend him for life in a submarine. Conditions are unnatural from the time he leaves the ground until he returns. There are many obstacles to be overcome. He flies in an atmosphere deficient in that oxygen which is the "breath of life."

The pilot is the heart and brain of the whole flying apparatus. Parts of the airplane may break without serious result, but when the pilot breaks, even momentarily, nothing is left to direct the flight.

To accomplish the best results, a comprehensive program to be followed in the selection of fliers was undertaken, providing for the standardization of both tests and examiners. Sixty-seven military units were established, each examining from 10 to 60 applicants a day. The figures show that 70.7 per cent of the applicants were qualified. The large number of applicants made it possible to maintain the highest standard in selecting men.

In the same spirit with which the United States determined to supply the American air fighters with as good, if not better, planes than those used by the enemy, it was decided that the American aviators must be as good, if not better, than those of the enemy. The outcome of any encounter might easily depend upon which combatant possessed the better vision and other special senses, the better nervous system and the better mental and physical equipment in general.

Each applicant received a complete physical examination embracing all the features ordinarily required of men entering the military service and, in addition, comprehensive and extensive tests of the special senses of vision, hearing and motion sensing.

Classification of the Flier

It is important to classify the flier for the kind of work he is physically capable of performing. Some men are not able to fly at higher levels than a few thousand feet without serious deleterious effects, while others can operate at much higher altitudes. It is necessary to know a flier's limitations before his training is specialized, for the saving of time and money and, in fact, of the flier himself. It would be an evident waste to train a pilot for combat work and then find he was only physically capable of doing bombing at a relatively low level. To accomplish this classification, branch medical research laboratories were placed in the flying fields, which by appropriate tests on the rebreather machine, developed at the parent institution at Mineola, classified the fliers.

The work of these laboratories demonstrated that 61 per cent are capable of flying to 20,000 ft. or more, 25 per cent should not fly above 15,000 ft, and 14 per cent are unsafe above 8000 ft.

The rebreather is used also to determine temporary unfitness for altitudes, due to some intercurrent illness, dietary indiscretion or staleness from prolonged flying.

Night bombing is carried out at altitudes as low as 300 ft. Day bombing, in order not to reveal the objective of the flight and to guard against concentrated anti-aircraft fire, may call for flights at very great altitudes. Reconnaissance machines rarely get to great altitudes, owing to the necessity for more or less close observation of the ground. Machines cooperating with the artillery in making range corrections for batteries, do not often work above 6000 or 8000 ft.

The Flack bag was the prototype of the rebreathing apparatus which has been developed in the medical research laboratory. By this apparatus the aviator rebreathes air confined in a tank, from which he gradually consumes the oxygen. As the percentage of oxygen decreases, the flier, in effect, is slowly ascending to higher altitudes. In the course of 25 to 30 min. he lowers the oxygen content of the air in this tank to 8 or 7 per cent, which is equivalent to attaining altitudes of 25,000 to 28,000 ft.

Another means of attaining the same result is by the diluting apparatus, which supplies directly to a mask over the face a mixture of air and nitrogen in whatever proportion is desired. All of these tests have been standardized and confirmed by the low-pressure tank, in which the air is rarefied to correspond to any given altitude.

The effect of low oxygen upon the mental processes varies greatly in the individual. He usually becomes mentally inefficient at an altitude at which there is as yet no serious failure of his vital bodily functions. By simple tests of mental alertness during rebreathing it is easy to determine that one flier becomes mentally inefficient at 15,000 ft., in sharp contrast to another who has his full mental powers up to and beyond an altitude of 25,000 ft.

Oxygen-want exaggerates any latent defect of the eyes. Crash reports have demonstrated that a large proportion are due to eye defects.

"Stunting" is essentially an internal-ear problem. During and after rapid turning the flier's brain is receiving impulses from his semi-circular canals. In a normal individual nothing can control or alter the sending or receiving of these impulses, which produce sensations of motion. Fliers vary greatly in their ability to interpret correctly the significance of these impulses. Experience alone enables them to familiarize themselves with their meaning. Those who develop the greatest ability in their interpretation naturally fall into the scout-pursuit class. Those who, in spite of training, are still disturbed or bewildered by stunting are reserved exclusively for straight flying.

The Maintenance of Efficiency

After a certain amount of continuous service the flier begins to show unmistakable signs of deterioration. Until the Air Medical Service went to work, fliers were permitted to continue until they broke. Their breaking was signalized sometimes by simple failure to return from behind the enemy lines; sometimes by becoming mentally and nervously exhausted to the extent of permanently unfitting them for flying.

The rebreathing test is valuable also in determining this staleness in fliers, caused by frequent exposure to high altitudes. Incipient cases of the deterioration in efficiency caused by oxygen-want are detected easily by the rebreather. Then it is possible to ground a man for a certain period to enable him to recover entirely, whereas if this condition were not detected, it might progress to a point where it would be impossible for the man to regain his former efficiency. When staleness becomes marked the flier is liable to faint in the air, thus losing his life and wrecking his machine. Periodical examinations are made to detect staleness.

While it was not possible to arrive at exact percentages, estimates made at the time of our entrance into the war, based upon information from Italy, France and Great Britain, indicated that not more than 2 per cent of the aviation losses in active service were caused by the enemy. Failures of the airplane were responsible for slight losses only, due, of course, to the rigid inspection of the machines. Statements from all sources agreed that of the total number of fliers permanently out of the flying service, not more than 8 per cent could

be attributed to mechanical shortcomings of the airplane or engine. The remaining 90 per cent loomed large when it was realized that this proportion represented trouble in the flier himself. Therefore the "Flight Surgeon" was authorized to keep aviators physically fit and to study the causes of accidents attributed to the failure of the man.

It was observed that more than half the injuries in crashes were caused by the flier striking his head against the cowl. The cowl was cut out to give the flier more room in front, and this change has practically eliminated the head injuries. A safety belt was fastened to the machine by a simple rubber shock absorber, and since this has been done the number and extent of injuries to the upper abdomen and ribs have been decidedly reduced. The problem of enabling the flier to withstand the glare reflected sunlight above cloud banks was solved by furnishing him with the Noviol type of goggles. The Dreyer oxygen apparatus is used to compensate for his lack of sufficient oxygen in high altitudes. This apparatus has been modified and perfected so that it is now possible to supply a flier automatically with the correct amount of oxygen for the altitude at which he is flying.

Within the last few months an apparatus has been perfected whereby students may acquire flying experience and training without leaving the ground. This machine, known as the Ruggles orientator, is a modification of the universal-joint, composed of three concentric rings pivoted so as to permit the fuselage, which is also pivoted within the innermost ring, to be put through every possible evolution experienced in actual flying except forward progression.

An analysis of "crash reports" shows that a large number are due solely to failure to come out of the spinning nose dive or tail spin. The student failed in these maneuvers because he had not learned by sufficient previous experience to compensate for his dizziness. The new apparatus gives the flier experience until he becomes familiar with the various sensations.

Another method of educating the student is by flying calisthenics. By daily turning and tumbling exercises he becomes accustomed to positions and movements in which at first he is awkward and bewildered.

It has become evident during the last nine months through activities of nutritional survey parties of the food division, Surgeon General's Office, that there is a great need in each aviation camp for a nutrition officer. The nervous system is more highly differentiated than the muscular system and more easily upset by improper food. It has been shown that a nutrition officer with special knowledge of food values should supervise the messes of all cadets and officer fliers to keep up efficiency.

Under date of Nov. 20, 1918, General Pershing said in a report to the Secretary of War: "Our aviators have no equals in daring or in fighting ability, and have left a record of courageous deeds that will ever remain a brilliant page in the annals of our Army."

Radio and Aerodynamic Investigations

A thorough study of vacuum tubes for use in transmitting, receiving and amplifying is in progress; a study of insulating materials used in radio apparatus; the development of a permanent-contact crystal detector; the development of a high-frequency oscillographic equipment, and the furnishing of standards for use in radio development are among the subjects handled in connection with the production of radio apparatus for military purposes.

Bomb-dropping devices have been tested and compared. The head resistance and other characteristics of airplane bombs have been measured to provide data for computing the trajectories. Machine-gun sights for airplane use, with automatic adjustments for speed have been tested and adjusted in the wind-tunnel. Hundreds of pitot tubes and pitot-venturi combinations for measuring the speed of the airplane have been calibrated. The head resistance of many types of engine-radiator section has been measured. Small variable-pitch propellers for driving the generator used in radio signaling at constant speed, independently of the speed of the airplane or engine were perfected through wind-tunnel tests and later tested in large numbers.

Radiation, Ignition and Carburetion Problems

The necessary apparatus has been designed and constructed to study the heat transfer characteristics of radiator cores used in airplanes. The performance of more than 85 different types of core has been studied in this apparatus at reduced pressure and high rates of air flow. Head resistance measurements have been made on these cores in the 54-in. wind-tunnel. The results of these experiments have shown that certain types of core in use today may absorb two or three times as much of the engine power as other types and as much as 25 per cent of the total power developed by the engine.

Experiments on the head resistance of a model fuselage fitted with a nose radiator have shown that the power absorbed by the resistance of a nose radiator may be as much as 40 per cent greater than that absorbed by a radiator more suitably placed. To afford maximum efficiency, a radiator must be designed for its particular air speed and position on the airplane. The results of this investigation give the necessary data for the design or selection of radiators for all air speeds and for various locations.

Investigations have been made on various problems connected with spark-plugs and other ignition apparatus used on airplane engines. This work has resulted in the development of a new porcelain for spark-plug insulators which is definitely superior electrically and mechanically to any previous commercial product. The results have led to the use for aviation work of several high-grade commercial porcelains not previously considered for this purpose.

In the carbureter testing plant the work has included a detail study of the changes in mixture proportions that occur with throttle manipulation under the conditions of atmospheric pressure and temperature existing at and between ground level and 33,000-ft. altitude. This work has resulted in the development of suitable control of the mixture under throttle manipulation at any level above the earth's surface and in the development of methods and devices for automatic correction of the variations in mixture proportions ordinarily occurring in passing from ground level to an altitude of 33,000 ft.

An important group of problems which engaged the attention of the Bureau of Standards was that relating to the production of light aluminum alloys and the improvement of their mechanical properties. Thus, new manufacturing methods were developed for a well-known rolling and forging alloy by which both the ease of its production was increased and its physical properties improved. Studies were made of the corrodibility of various alloys, while mechanical and metallurgical tests were made of a variety of different compositions of al-

loys giving most valuable information for the guidance of the designer of engines and planes.

Airplane Dopes, Varnishes and Fabrics

Specifications for acetate and nitrate dopes were prepared at the Bureau with the cooperation of dope manufacturers, airplane constructors and representatives of the government. Simultaneously, dopes manufactured in this country were examined in accordance with the specifications and list of products prepared which were approved for use on Government aircraft. After much controversy, the use of acetate dopes containing tetrachlorethane was forbidden because of the toxic effects of this compound. Many proposed methods of fireproofing dopes and fabrics have also been examined. A commercial method of preparing and stabilizing lactic acid testers was devised for use in acetate dopes to conserve the products of acetate of lime. A transparent silk fabric for possible use in obtaining low visibility has recently been perfected. Lately work has been in progress on the pigmentation of dopes with a view to protecting the dope film from the deteriorating action of sunlight and thus prolonging its life, at the same time dispensing with the use of enamels, thus saving one step in production. The use of pigmented dopes will also conserve cellulose acetate.

Investigations of methods for making wooden parts of airplanes water resistant showed that a good grade of spar varnish was satisfactory, and a specification for such a varnish that could be produced at low cost was prepared. The same varnish has been found to be a satisfactory coating for doped linen or cotton, used either as a transparent varnish or as the basis of a vehicle for pigmented coatings. This may be used on both wood and metal.

The Grade A cotton fabric now being supplied to the Air Service compares favorably with the linen regarding weight, has a much higher factor of safety, a greater tear resistance and dopes up to satisfactory tautness. The life of any fabric is dependent entirely upon the life of the dope, and therefore the cotton has as long life as the linen.

As a result of more recent investigations by the Bureau of Standards, another distinct fabric has been evolved which is 25 per cent lighter than any linen fabric now in use, and is materially stronger.

Signal Corps Research Division

At the time of the signing of the armistice, the science and research division of the Signal Corps had in progress 64 problems.

A summary of the most important results actually achieved up to that time is given herewith:

(1) The aeronautic instruments section, in addition to fulfilling the function specifically assigned to it of writing all the initial specifications for aeronautical instruments in use on planes, and in working continually with the instruments in production to detect imperfections and make suggestions for improvement, designed and developed wholly within its organization, through the activity of its chief, Major C. E. Mendenhall, a new and improved pitot-venturi tube for use in the determinations of airplane air speed. This instrument was actually put into production and 37,000 ordered

(2) Major Mendenhall and Lieut. R. C. Williamson have cooperated with the General Electric Co. in the development of a new and improved compass, 10,000 of which were produced. This compass is now in use on planes for the American Army

(3) The science and research division cooperated with the Eastman Kodak Co. in the development of an entirely new film camera which is in production and which is the only film camera in existence capable of taking the standard size 18 by 24-cm. pictures. This camera is entirely automatic and capable of taking 100 pictures without refilling

(4) The science and research division with the assistance of the Burke & James Co. of Chicago developed a new plate camera which is a modification of the French De Ram. It is semi-automatic, carrying 50 plates. It has been accepted and is now in production. Both this photographic development and the one mentioned under (3) were made possible solely by the bringing together of a highly trained scientific group in the photographic section of the science and research division

There would have been practically no possibility of the attainment of these results without such a group. This photographic group constituted one of the sections of the science and research division until about July 1, 1918, when it was transferred to the production division. The development of photography during the present war, due to the advent of the airplane, has placed it permanently among the indispensable agencies for successful military operations. The older methods of recording personal observations have been superseded entirely by the far more accurate and reliable photographic record. A complete detailed photographic map must now be made daily of each sector immediately in front of an army, and by carefully matching these maps and by intensive study of each individual area, the maze of trenches, entanglements, machine-gun nests and shell-holes can be accurately analyzed. It is worthy of notice that 17,000 photographs were taken by the British Army before the operations at St. Quentin in order that a relief map of the sector might be made before the drive against the Germans. By this map, every detail of the work to be performed by the British troops was planned. By a series of consecutive photographs taken at regular intervals by a moving-picture camera an accurate and reliable picture of a military road, for instance, showing all the details to scale can now be made in a few minutes. With the aid of the camera the detection of camouflage is possible where the human eye would fail

(5) Dr. Gordon S. Fulcher, working in collaboration with the Miller Rubber Co., developed a leakproof tank simultaneously with the development of a similar tank in England, achievements of the utmost importance for the lives of Allied aviators. The Fulcher tank was ordered placed upon all fighting planes

(6) Major C. E. Mendenhall and Lieut. John T. Tate, with the assistance of the General Electric Co., perfected a trench signalling lamp which, after testing at the front, was ordered sent over in considerable numbers and will probably constitute a standard American projector for the United States Army

(7) Major R. W. Wood developed a telescopic signaling device using a 6-volt 2-amp. lamp. This lamp was tested at the front and favorably passed upon by the A. E. F. It has made light signaling in broad daylight over a distance of 18 miles possible. General Pershing ordered a considerable number of these sent to the A. E. F.

(8) Major Wood also developed a secret daylight signaling lamp which has a range of 5 miles. This also was ready for shipment abroad at the time of the signing of the armistice

(9) Secret signaling at night, with the aid of ultraviolet light, was perfected by this department, working in collaboration with Norman Marshall. With simple signaling telescopes of the sort mentioned above, using only a 6-volt 2-amp. lamp, secret signals have easily been sent 6 miles. Major Wood also developed new means of adapting this method to the problems of signaling to airplanes and secret signaling between

convoys and obtained thereby a device which will be of much use in peace as well as in war

(10) W. J. Lester, S. R. Williams, Capt. B. J. Sherry and Sergt. W. H. Redman developed propaganda balloons which have a range of more than 1000 miles. This is an accomplishment which is invaluable to the future development of aviation, particularly with reference to transatlantic flights, whether in peace or in war

(11) Dr. W. F. G. Swann and Dr. Gordon S. Fulcher gave invaluable service to the balloon section by making an elaborate and highly important study of the causes of fires in balloons and sending to the balloon officers in the balloon section directions for the prevention of such fires

(12) Dr. H. N. Russell and Capt. J. P. Ault developed means for navigating airplanes with the aid of the sextant and an artificial horizon. They also developed means of speedy reduction of observations so that an observer in a plane can locate himself with an average error of not more than 10 nautical miles within 5 min. after he makes his observation. This achievement is of great value for the problem of long flights

(13) Lieut. John T. Tate and Otto Mohr developed a portable landing light for use on aviation fields. This device was officially tested and favorably reported upon by the Division of Military Aeronautics. It is now in use at some fields and recommendation has been made that two complete units be made a part of the permanent equipment of all aviation fields

(14) Dr. Harvey N. Davis represented the Army in the development of the helium program and contributed in a large measure to the great success which has been attained in that work

(15) The chemical section under Dr. H. D. Gibbs developed new methods of producing acetone, which will make it possible to obtain this substance for one-fourth the price the Government is now paying

(16) The chemical section, through the activity and energy of Dr. L. E. Wise, developed sensitizing dyes which previously had not been obtainable at all in the United States and which were urgently needed in airplane photography

(17) Capt. Herbert E. Ives and Dr. F. A. Saunders, in collaboration with I. W. Priest of the Bureau of Standards, made notable contributions in the development of color filters for detecting camouflage and increasing visibility. Forty thousand of these devices are now in use in the Army and Navy

(18) Dr. Wilmer A. Duff's section worked out the only method which has been developed thus far for the accurate, experimental determination of bomb-trajectories. This is of primary importance in obtaining precision in bombing. It will have peace uses as well as war uses

(19) Dr. Duff's section also developed a bombsight stabilizer which has reduced the main error now made in bombing, namely, the error in the determination of the vertical, by more than three-fold. When it is remembered that a three-fold increase in the accuracy of bombing is precisely equivalent to the multiplication by three of the production of bombing planes, the importance of work of this kind scarcely needs comment

There are probably a dozen of the 19 developments mentioned above, each one of which is worth more to this country than the total amount spent upon the establishment and maintenance of the science and research division from its inception up to the present time.

Vacuum-Tube Development Work

In a summary of the engineering achievements of the Signal Corps during the war, the development of radio apparatus forms a large part. Inasmuch as the vacuum tube occupies so prominent a role in almost every kind of radio apparatus, an outline of its development logically precedes discussion of the radio sets.

The application to radio inter-communication of the vacuum tube, perhaps more properly called the thermionic tube or bulb, is one of the most interesting developments in the whole field of applied science. Not only has it made possible what has been justly heralded as one of the most spectacular achievements of the whole war, the airplane radiophone, but the confidence growing out of the extensive experience with the vacuum tube in warfare, coupled with its extreme adaptability, has resulted in a rapidly increasing amount of radio development involving its use.

The vacuum tube was known in various forms before the war. Following extensive experiments with the so-called "Edison effect," Fleming, some years ago, produced the well known Fleming valve, a current rectifying device, capable therefore of being used as a detector of radio signals. This device contains two elements, an incandescent filament emitting electrons and a plate upon which an alternating voltage is impressed, both placed within an evacuated bulb. Later Dr. Lee DeForest introduced an important modification by placing a wire mesh or "grid" between the filament and the plate. A small voltage variation on this grid produces the same current change through the tube as would a much larger voltage variation on the plate, thus adding amplifying properties to the detector characteristics of the Fleming valve. DeForest called his device the "audion." Later, with superior facilities for evacuation available and with a more intimate knowledge of the laws of thermionic emission from hot bodies, improvements and modifications were made in the audion or vacuum tube by both the General Electric Co. and the Western Electric Co., the latter designating its product as the "vacuum tube," and the former, the "pilotron."

In addition to acting as detectors and amplifiers, as mentioned above, vacuum tubes can function in two other important ways:

(1) As Oscillators In properly designed circuits containing inductance and capacity they will act as radio frequency generators, for use in transmitting or receiving radio signals

(2) As Modulators By suitable connection to an oscillator circuit or antenna, they can be made to vary the power radiated so that the envelopes of the waves transmitted shall have any desired wave form, as for example, the speech waves from an ordinary telephone transmitter

The most striking use made of vacuum tubes prior to the time we entered the war was the transmission of speech by radio from Washington to Paris and Honolulu, during the experiments carried out by the American Telephone & Telegraph Co. and the Navy Department. Vacuum tubes were used as the radio frequency generator for transmitting, and as the detector and amplifier in receiving.

When the United States entered the war, vacuum tubes were already in use by the Allied forces for various signaling purposes. The French particularly had been quick to recognize the military value of vacuum tubes and had, previous to June, 1917, developed very creditable tubes and apparatus. In America, tubes were in limited use as "repeaters" on telephone lines, and as detectors and amplifiers in laboratories and radio stations. The total production in this country, however, did not exceed 300 or 400 a week.

Early in our participation in the war, it became evident that vacuum tubes would be required in very large quantities to meet the growing demands for radio com-

munication and signaling. It was equally evident that service conditions, not hitherto anticipated, would require great mechanical strength, freedom from disturbance under extreme vibration and uniformity of product sufficient to make possible absolute interchangeability of the tubes in sets, without the necessity of readjusting when changing tubes. To these conditions must be added that of minimum size consistent with dependable operation.

To make such a device with its complicated yet accurately constructed metallic system within a practically perfect vacuum is no small problem even when done in the laboratory on the individual unit basis by a skilled operator who appreciates the delicacy of the job. To turn out tubes by the thousands under factory methods involves almost infinitely greater difficulties. How well certain companies, in collaboration with the Signal Corps, have succeeded in solving these difficulties is indicated by the fact that recently the total rate of production in the United States of high quality standardized tubes was considerably in excess of 1,000,000 a year. This rate of production could be made many times greater on short notice.

As an example of the difficulties which this quantity production has involved may be mentioned that of evacuation. The degree of vacuum required is such that unusual methods of exhaust are necessary. The heating of the tubes in electric ovens is supplemented by heating the elements of the tube by excessive filament and plate electrical power input. Molecular pumps are employed, necessitating an extremely large number of pumps to handle quantity production. Special treatment of metal parts prior to assembly is employed to reduce the gas given off by them during the exhaust process.

Another problem is that of making the complicated metallic structure of all tubes exactly alike to insure identical electrical properties. As an indication of progress in this direction, it may be stated that one company is prepared to manufacture, in quantity, a certain tube in which the clearance between filament and grid is only 0.03 in., the allowable variation being of course only a small percentage of this.

Manufacturing in quantity involves careful inspection. The problem of specifying definitely the required performance of tubes, the development of adequate testing specifications and the placing of standardized testing and inspection methods, personnel and equipment in the various factories so that tubes manufactured at different times and places would, after passing inspection, be uniform and interchangeable; these questions were entirely new and have been solved almost exclusively by the Signal Corps engineers.

Tubes developed by the Signal Corps may be divided into two general classes, the tungsten filament types as designed and manufactured by the General Electric Co. and the DeForest Radio Telephone & Telegraph Co., and the coated filament or Wehnelt cathode types as developed and manufactured by the Western Electric Co. The coated filament tubes have thus far proved superior to the tungsten filament tubes for Signal Corps use. Both classes have been standardized as regards base, exterior dimensions, filament current and voltage and in addition, plate voltage and output for transmitting tubes and amplifying power and detecting power for receiving tubes. Except in certain special cases, the Signal Corps uses two types of tubes, one for transmitting and another for receiving. The French and the British have been using one type for both transmitting and receiving, but present tendencies of the British are toward different tubes for different duties.

Vacuum tubes are now employed for electric wave detection, radio frequency and audio frequency amplification, radio telephony, particularly in the airplane radiophone, continuous wave radio telegraphy, voltage and current regulators on generators and for other miscellaneous purposes. However, varied as are the applications at present, the uses, actual and potential, growing out of war development work have proved that the art of vacuum tube engineering and the application of its products to radio engineering, telephone and telegraph engineering and particularly to electrical engineering in general are still in their early infancy. That vacuum tubes in various forms and sizes will, within a few years, become widely used in every field of electrical development and application is not to be denied.

The engineering advancement accomplished in less than two years represents at least a decade under the normal conditions of peace, and our profession will, it is hoped, profit by this particular salvage of war which offers perhaps the most striking example known of a minimum "time-lag" between the advanced "firing line" of so-called pure physics and applied engineering.

Airplane Radio Telephone and Telegraph Sets

Speech was exchanged between airplanes 25 miles apart in October, 1918, and sample sets were sent at once to the Army in France for trial. Several thousand sets were ordered and have been completed and distributed to flying fields here and to the Air Service in France.

The satisfactory performance of this apparatus has resulted in a new type of military unit known as a voice-commanded squadron. The commander of an air fleet directs the movements of the individual units in any manner desired; the effectiveness of the squadron as a military machine is thereby enormously increased. Other uses are in communicating information from airplanes to ground stations and in directing one or more airplanes from a ground station. Innumerable applications will be evolved as the possibilities are realized. The essential elements of the airplane radiophone are the power equipment, the radio equipment and the antenna. The power equipment includes a double-voltage direct-current generator driven by an air fan, with a vacuum-tube voltage regulator.

The radio equipment consists of the vacuum tube transmitting and receiving set and the special telephone transmitters and receivers. The development of a transmitter which is affected by the human voice and not by the enormously greater engine and wind noises is one of the principal features of this set. Similarly, to shield the ears of the aviator from the same noises required a special combination of sound-insulating materials surrounding the telephone receivers and suitable for use within an aviator's helmet. The antenna originally consisted of a flexible copper wire several hundred feet long, unreeled by the aviator and trailing almost horizontally behind the airplane. Modified antenna using much shorter wires fixed to the framework are now used.

The operation of the sets is extremely simple, all adjustments being made before leaving the ground. The only manipulation required of the aviator is that of the change-over switch to shift from talking to listening.

The principal use of radio communication made during the war was in sending radio telegraph signals from observation airplanes for controlling artillery fire. The French developed a set which consisted of several units, making the installation and operation complicated. The

Signal Corps developed a self-contained set, which has been demonstrated to be far superior to any other airplane set. It consists of three units, first, the 200-watt, 900-cycle alternating-current generator, driven by a regulating air fan and containing in a streamline case attached to the generator all the elements of the radio set. This radio apparatus is of the synchronous spark type, with four spark tones and nine wave lengths. The weight of the complete unit is only 23 lb., and the size 6 by 6 by 26 in. The regulating air fan maintains the speed of the generator within 4 per cent of 4500 r.p.m., with air velocities between 60 and 200 m.p.h.

The remaining units in the complete set are a variometer or tuning coil, with antenna ammeter attached, and the antenna system, comprising a reel, insulated bushing and trailing antenna. When it is realized that voltages of 30,000 or more are produced by this set, the difficulties of insulation in such restricted spaces will be appreciated.

Ranges of communication of 100 miles have been accomplished with this set.

Airplane Direction Finder

One of the principal problems of airplane navigation has been the evolution of a suitable compass, particularly for night bombing work. Magnetic and gyroscopic compasses have limitations at present which make reliable air navigation by dead reckoning impossible.

The use of directional effects of loops or coils for receiving radio signals has resulted in the development of a radio compass for airplanes which gives positive information to the aerial navigator and enables him either to locate his position by triangulation with respect to two beacon land stations or to fly at any given angle with respect to a certain beacon station.

The apparatus consists of two principal parts, the antenna coils and the tuning and amplifying apparatus. The antenna coils are mounted in the fuselage of the Handley-Page airplane, with suitable means for rotating in azimuth. The amplifier is extremely sensitive, consisting of a detector and six-stage amplifier. A novel feature of the amplifier is the use of iron-core transformers for frequencies of 100,000 cycles.

The direction of the beacon land radio station is determined by the maximum strength of signals, in a highly ingenious manner developed originally by the British. The precision of the directional effect is remarkable. In fact the radio direction finder may well be called a radio eye, by which the aerial navigator sees one or more radio lighthouses which are sending identifying signals to guide him on his way. These lighthouses, furthermore, have certain advantages over the normal lighthouse in that their ranges may be much greater, and they are not invisible in the day time nor obscured by fog and mist.

The remarkable advances made during the last 18 months have resulted in the application of radio communication to practically every phase of military aviation. Commercial and military possibilities have, however, hardly been touched as yet. It is believed that radio apparatus will soon be as essential on aircraft as it now is on ocean going steamships, and that its use will enormously increase the effectiveness of aircraft for all purposes.

The Liberty Engine

At the time this country entered the war, in April, 1917, there were being built in the United States only four makes of engine that were developed so far as to be considered of any military value, and even these were useful only for primary training. We had no engines

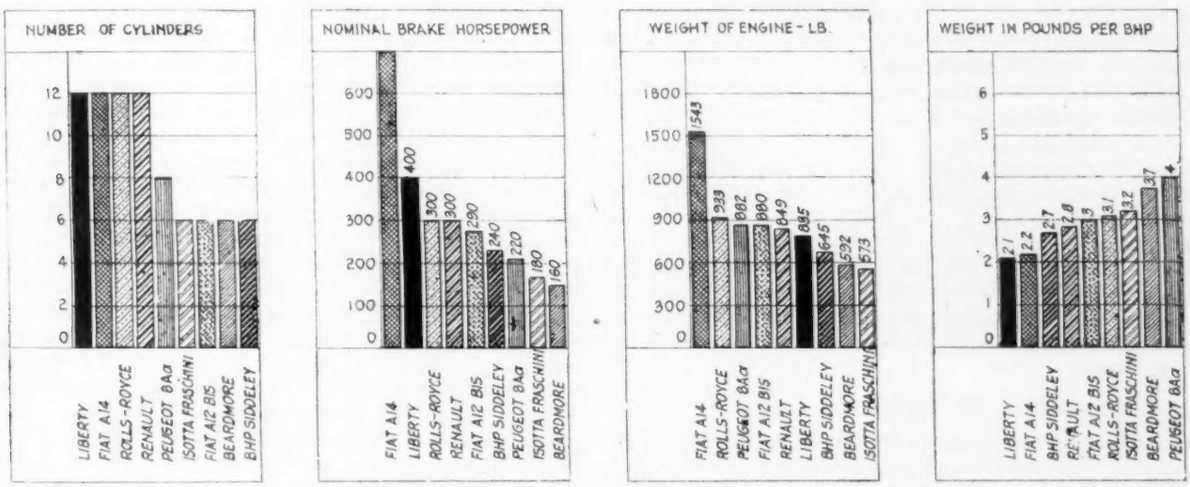

FIG. 5

at all suitable for service on the battle front, or even for the advanced training of pilots. The largest engine of domestic manufacture developed about 220 hp. and had not proved satisfactory when judged from the standpoint of combat service requirements. The others ranged in power from 90 to 135 hp. It, therefore, was evident that the existing American engines could be used for preliminary instruction purposes only and that their further manufacture should be limited to the training requirements. This was done, with the result that by far the greater portion of the primary training of pilots has been conducted with the Curtis OX-5 90-hp. engine, the quantity production of which was early obtained. This engine was particularly valuable, owing to the very satisfactory training plane which had been designed around it. The Hall-Scott A7-A 100-hp. engine was also extensively used at first until the production of the Curtiss engine could be brought to a point to meet all demands for primary training.

Two European engines, the Gnome 100-hp. and the Hispano-Suiza 150-hp., were being put into production in

this country early in 1917, by the General Vehicle Co. and the Wright-Martin Aircraft Corporation respectively. These firms had obtained contracts with Great Britain and France, but were experiencing considerable difficulty in getting production under way. The production of the first Gnome engine was not completed until a period of more than nine months had elapsed, during all of which time English experts were present in the contractor's plant and aiding the manufacture. In the case of the Hispano-Suiza, notwithstanding the assistance of a group of French experts sent over to help get it into production in the minimum time, 13 months was required to get the first production engine on the test block and another month before the first delivery was made. Preparation periods were filled with the most costly experiments and the development of methods and tools for performing the intricate operations required by the design of these engines; all of which expense and delay had cost our Allies dearly.

The Gnome and Hispano-Suiza engines represented the highest product of European design and were in a perfected and standardized state, according to foreign practice and conditions, when their production was undertaken in this country. Nevertheless, the changes involved in adapting them to manufacture by American methods, and the development of expert workers for those operations which could not readily be so adapted, required so much time that the advances made in aeronautical engineering rendered such engines largely obsolete for service at the front by the time they could be produced in sufficient numbers to supply any material portion of the requirements.

These two engines were, however, of unquestioned value for advanced training purposes, the Hispano-Suiza in particular being a dominant factor in this work. Later the Le Rhone 80-hp. was put into production by the Union Switch & Signal Co., and, by proper utilization of the lessons learned in the case of the other two foreign engines, reasonably satisfactory progress was made in manufacture. This engine, too, was used for advanced training work.

Inception and Experimental Development

One of the serious mistakes which the Allies had fallen into at the time the United States entered the war was the development of a multiplicity of types of engine and plane which made it impossible to have a large number of any one of these. As a further consequence, the trained personnel on the ground to operate and repair the machines had grown to such a proportion that it was estimated from 30 to 50 men were required to keep each one of the many types of planes in the air on the fighting line. Manifestly, unless this large number of trained men per fighting plane could be reduced by some means it would be hopeless to expect within a reasonable time to put into the air thousands of flying planes, because a single thousand machines on this basis would require from 30,000 to 50,000 men in attendance.

The experience obtained in getting two foreign engines into production in this country under our manufacturing methods, so thoroughly demonstrated the futility of attempting any such solution of our service engine problem as to at once eliminate its continued consideration. It was realized that copies of foreign designs could not be available in time and in adequate size or number to answer the demand for an overwhelming air force at the front. American air performance would have been very small indeed if limited by such a handicap as this.

Moreover, in spite of the fact that a technical commission was at once organized and dispatched for the purpose of getting first-hand information on the front and in the aircraft centers of Europe, it was unthinkable that this country should sit idly by and wait perhaps months for the final definite report which should decide the nature and extent of our part in the Allied aircraft program. Since the most successful airplanes are designed around specific engines, and the engine involves the greatest expenditure of time and effort in development, it was apparent to a few of us who were in close contact with the situation that it would in all likelihood be possible to design, develop and produce an entirely new American engine, embodying characteristics which would render it particularly adapted to manufacture under American conditions, in less time than would be required by the commission to determine the particular European engines that offered the best approximation to the various exacting requirements of service and production, plus the time to get it in production in this country. It was decided, therefore, that our efforts should be directed along both these channels simultaneously and in addition to purchase in Europe whatever service equipment might be available, to tide over the interval while we were getting into production.

It is apparent that the fundamental unit of engine design or construction is the cylinder, and that the evolution of engine power rests mainly with the unit power capacity of that cylinder which could be taken as representing the largest practicable size sanctioned by the state of the art at that time. Starting with the foundation of this cylinder then, it was the most direct reasoning to conclude that all requirements of the service for engines of varying power capacities could be most logically met by combining these unit cylinders into groups of whatever number were required to produce the several sizes of engines desired. This was done, and the cylinder size of 5-in. bore by 7-in. stroke was selected, after a careful examination of the performance of both American and European engines of the then most modern design, as being the largest that could be relied upon to give satisfactory service. While originally designed to produce approximately 28 hp., this cylinder has been so developed as to yield at present more than 40 hp. as the result of somewhat increasing the speed and altering the functioning characteristics. The standard unit cylinders were to be used in engines having four or more cylinders each and yielding the following power output:

Number of Cylinders	Original Rated hp.
4	110
6	165
8	225
12	335

Thus, for the first time in the history of the aeronautic engine for military uses, a truly comprehensive design plan was evolved which in a simple and direct manner provided for the production of a whole line of engines of wide power capacities but composed of units that were highly standardized and therefore could be really manufactured, instead of being merely built. This was, and is, the only way in which this country could meet the requirements of this most vital part of the program.

It must not be thought, however, that such a revolutionary decision was easy to make, or adhere to when

made, in the face of all kinds of adverse criticism, some of which seemed to be based upon adequate grounds. The development of new types of aircraft engines theretofore had been such a time-consuming matter that it was generally regarded as a thing to be avoided if any already-developed engine could be found anywhere which would at all answer the requirements. Thus the numerical preponderance of opinion was against the possibility of a standardized American engine being designed, developed and produced in large numbers, in anything like as short a time as would be required to duplicate some European engine. The nation may well render thanks that its destinies in this particular were guided by such a far-seeing and courageous group of men, who had the ability to formulate such plans and then to enforce their realization.

You are all familiar to some extent with the history of the design and construction of this engine—how Lieut.-Col. J. G. Vincent of the Packard Motor Car Co., and E. J. Hall of the Hall-Scott Motor Car Co., laid down the general features and got out the first assembly drawings personally between mid-day of May 29 and the afternoon of May 31, 1917, working in Col. E. A. Deeds' apartment in a Washington hotel in response to a request for a report on the aircraft engine situation, which came from Howard E. Coffin, chairman of the Aircraft Production Board, the Chief Signal Officer of the Army, Col. Edward A. Deeds, chief of the equipment division, Signal Corps, and Col. Sidney D. Waldon, assistant chief; how the order to build ten sample eights and twelves was given as the result of the approval by the joint conference of the Army and Navy Technical Board and the Aircraft Production Board; how the first engine, an 8-cylinder, was built in one month as a result of the enthusiastic cooperation of some 10 manufacturers, each of whom produced those parts for which he was best fitted; how the first sample 12-cylinder finished its official 50-hr. endurance test 82 days from the time the order for samples was given, and the total elapsed time during this test was only about 55 hr., a record-breaking performance, and how the success of this endurance test definitely removed the engine from the experimental stage to the realm of proved engines.

A very gratifying endorsement of this standardized engine project came from the late Col. R. C. Bolling, whose untimely death in France cost the American Air Service one of its most valuable officers, and from Lieut.-Cols. V. E. Clark and Howard C. Marmon, members of the commission sent abroad to ascertain the requirements, which returned about this time, to the effect that a 400-hp. engine was urgently demanded at the front for the types of airplanes which it had been decided this country should supply, and that no engine of this size then existed in Europe.

Those of us who are familiar with the difficulties and disappointments involved in the design, development and perfection of any form of intricate mechanical device can readily appreciate the really remarkable accomplishment represented in the Liberty engine. Therefore, it is not at all surprising that the representatives of the Allies were for some time unable to believe the full truth of this accomplishment. They never had been able to obtain such action and were, naturally, fully convinced only after many varied and exhaustive tests. So well recognized did the value of the Liberty engine become, however, that the Allies had 16,741 Liberty engines on order at the time of signing of the armistice, and were constantly endeavoring to increase the rate of monthly delivery. Airplanes were being designed around this engine in all Allied countries and it was fast becoming the predominating aeronautical engine of the Allied cause.

It is of interest in this connection to note that this standardized engine has already been tested in the 24-cylinder model and shown results which prove that the original basic idea will provide for engines of any size which would have been required for any probable increase in airplane size during years of continuation of the war. The 16-cylinder was also proved by the success of the larger engine.

The experimental development of the Liberty engine has been in charge of a department entirely separate from that dealing with its production, the Airplane Engineering Department under Lieut.-Cols. J. G. Vincent and Howard C. Marmon. The work of this dedepartment has resulted in a continuous improvement of the power output and performance characteristics of the Liberty 12-cylinder, to such an extent that 526 hp. has been obtained with special fuel and detail changes; certainly a remarkable increase from the 335 hp. which the original design was intended to yield.

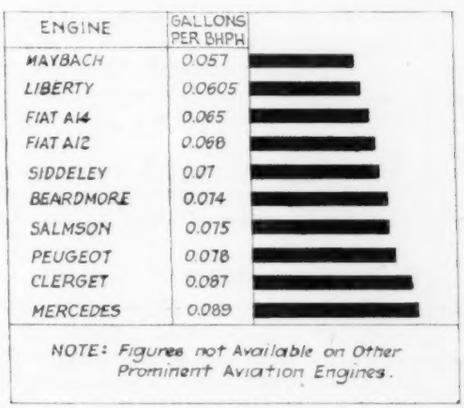

FIG. 6

While the weight of the service engine per horsepower has remained at approximately 2 lb., the maximum present development had reduced this figure to 1 2/3 lb.

PRODUCTION-DEVELOPMENT AND PRODUCTION

The record of production and production-development of the Liberty engine conclusively proves the wisdom of the decision to concentrate all efforts on this one engine for the major part of our program of combat engines. In common with all similar machines, many possible improvements and cost reductions became evident as the manufacturing processes and tools were evolved and experience was acquired in the actual production. Also, experience in the operation and adjustment of these engines led to alterations being made which resulted in increasing the power output; so that when we were informed that more power was desired than the 335 hp. which the original Liberty was designed to produce, the necessary steps were already known and the delay incidental to putting them into effect was small. The resulting power increase to about 375 hp. answered requirements for several months, when word was again received that more power was needed, and we again made such alterations as were required to increase the power to around 420 hp. The weight of some of the parts was

increased at this time so that the reliability might not be reduced.

The problem of production was placed in the hands of a separate department in charge of Lieut. H. H. Emmons, U.S.N., and the continuous assistance of such men as Henry M. Leland of the Lincoln Motors Co., C. Harold Wills of the Ford Motor Co., F. F. Beall, O. E. Hunt and Edward Roberts, all of the Packard Motor Car Co., were obtained by Major J. G. Heaslet, in charge of the Detroit district. The work of Mr. Wills which has the greatest value was the perfection of a new process for forging the cylinder blanks in sufficient quantities to supply all manufacturers, and which was so very effective that the problem of cylinder forging supply and cost was reduced to a minor consideration. The wisdom of the action taken is evidenced by the production of 1100 Liberty twelves in one year from the day when Messrs. Vincent and Hall first met and started a preliminary drawing, and of over 15,000 by the end of another six months.

It was perhaps to be expected that many criticisms would be leveled at an engine evolved under the conditions obtaining at that time and registering the large success which it represents, but all such have proved to be the result of misinformation regarding the conditions to be met and the fundamental ideas of design, or of lack of appreciation of the difficulties encountered in creating at a single stroke and without previous experience, an aeronautical powerplant so much larger than any then in existence.

The Liberty engine stands today as an achievement which for daring, constructive imagination and farsightedness will ever be a source of pride to the American people.

A Granular Theory of Armies

The one unchanging factor in warfare is the individual physical strength of a man. The soldiers of Cæsar's army were physically no stronger nor weaker than our own. On the average, a battalion or company of soldiers from one nation can march, for instance, just as far in a day as a battalion or company from any other nation, and this statement was equally true before the Christian era and is not likely to change in the future.

In consequence of this fact, military supremacy must be looked for primarily in the weapons and agencies provided by scientists and engineers and placed in the hands of these combatant units to multiply their military strength.

To illustrate, the day in the fourteenth century, when Berthold Schwartz or whoever actually invented gunpowder, put together charcoal, sulphur and saltpeter, he, by a scientific act, and at a single stroke, exerted more influence upon the development of warfare and indeed the history of the world since that time than many armies have accomplished by any mere physical qualities which they possessed.

Stated in another way, if our enemies in the recent great conflict had been made up wholly of civilizations like those of Turkey and Bulgaria, nearly all of the agencies which I have been describing during the past hour would have been utterly impossible of either development or production by them. There were no Liberty engines nor airplane radio sets evolved or made in this quarter, nor could there be such without outside aid.

It follows from this, that those civilizations which by their scientific and engineering training can create and manufacture these agencies, will and must control the fortunes of war in the future, or far better, apply these same agencies in a potential way to banish war from the world for all time.

The present war has made aviation in four years what it would have taken two decades at least to accomplish in time of peace, and has multiplied the reach and capabilities of the physical military unit to an extent which is only now in the beginning.

The organization of the American Air Service requiring, inter alia, the foundation of a new industry under the adverse conditions outlined above, involved a creative project worthy of the broad conceptions for which the United States is noted. When the United States entered the war, it was evident that the time was fast approaching when the reservoirs of raw material for the Allies were to be found only in the United States and that America's efforts should be so organized from the beginning as to furnish a continuous flow of this necessary raw material, not only for our own air program, but for those of the Allies as well. It was clear, for instance, that the spruce, the fabric, the dope and the oil must be produced as a part of our program on a scale to supply also the air programs of the Allies. It was always the general allied cause therefore which controlled the decisions in founding this industry, rather than the needs of the United States alone, and this was obviously the only correct point of view.

It is believed that the major decisions which had to be made by those in authority were accurately made and promptly executed, and that as a consequence the record of the United States Air Service during the war shows a creditable performance.

By a wise policy of readjustment, utilizing immediately our machines and our surplus aviators for the rapid expansion of the aerial mail and special passenger services, it will be possible to salvage for the nation a greater percentage of the money and energy invested for strictly war purposes than from any other feature of our war activities.

The general principles which governed in the making of this enterprise in all of its ramifications of material and personnel, and to which the success attained must be attributed, may perhaps be formulated as follows:

VICTORY CREED

To foster individual talent, imagination and initiative, to couple with this a high degree of cooperation, and to subject these to a not too minute direction; the whole vitalized by a supreme purpose which serves as the magic key to unlock the upper strata of the energies of men.

Vol. V December, 1919 No. 6

Comparative Characteristics of Anti-Friction Bearings

By FRED A. CORNELL[1] (*Member*) CLEVELAND SECTION PAPER

ACTIVE influences upon standards in anti-friction bearing design and production might be grouped as follows:

(1) War emergencies postponed any trends toward wider adoption of metric measurements
(2) Theoretical variances of type characteristics
(3) Contradiction in assembly practice
(4) Manufacturing usage in existing inch and fractional sizes
(5) Interchangeability in maintenance
(6) Fundamentals permitting progress

METRIC MEASUREMENTS FOR BEARINGS

The use of American-made apparatus in France had many peculiar effects. Among these was a considerable influence upon the use of metric measurements. Before the war it was quite generally assumed that the use of the metric measurement was growing; that it would ultimately supplant our inch and fractional system. However, the quantity production of interchangeable apparatus, with all of America's vigor, seems to have commanded so much respect for everything American that our system of measurements comes in for its share of perhaps undeserved recognition. This is admittedly a practical statement and does not attempt to discuss the advantages claimed for metric measurements.

One thing, the decreased number of requests for automotive parts manufactured to metric sizes is absolutely certain. This seems most noticeable in a few details of which I have intimate knowledge. For instance, there is an urgent demand in Europe for American-made automotive assemblies produced under our standard measurements.

In England in the development of the tank program they were hampered by a shortage of the type of anti-friction bearing used most largely up to that time. There seemed to be considerable prejudice against the ready adoption of the taper-roller bearing of American design, in spite of the fact that it had been admirably manufactured in England for over five years. However, this emergency shortage of the more widely used bearings gave the taper-roller bearing an opportunity which it improved. In the assumption of George H. Ralph, this situation can be summarized as follows:

> Owing to the excellent service given by taper-roller bearings and the number of applications which the ministry has been compelled to make because of a shortage of ball bearings, that term is now a household word with British designers; its advantages are being realized and prejudice removed

The initial demand for American-made bearings following this opportunity was for a quarter-million of fifteen different inch and fractional sizes for diversified postwar usages.

Writing on the subject of "The Metric System in Export Trades," the Commissioner of the American Institute of Weights and Measures has lately made the following statement:

> Here we have in a nutshell the case for the metric system in export trade. The investigation of that subject by the Institute of Weights and Measures contained in my report, published by the American Society of Mechanical Engineers, makes clear to anyone willing to learn that the call for metric sizes of manufactured products is absolutely negligible; the only call for that system in export trade being its use as a price unit of weight

It would appear therefore that the argument of adapting American standards to be interchangeable with metric practice is not supported by any general tendency in this direction.

VARIATIONS IN TYPES

The Society's effort toward standardization of all anti-friction bearings has unfortunately been based upon a thinly veiled purpose of interchangeability as to dimensions. The various types of bearing may be produced to interchangeable sizes but these sizes have wide variance in capacities, both radial and thrust. A taper-roller bearing is not interchangeable with the annular bearing even though the bore, diameter and width are the same, because the taper-roller bearing has inherent thrust and radial capacity and requires provision for adjustment; whereas the annular bearing is primarily a radial bearing and does not require adjusting mechanism.

A series of sizes for annular ball bearings is a function of the bore and the size of the balls; whereas, on the other hand, a series of sizes for a taper-roller bearing is a function of the bore only, the same roll being used throughout a series. This is made necessary by the fact that the apex of a cone angle for roll is a constant, and an increase of the number of rolls therefore increases the angle of the roll centers with the bore and, therefore, to a certain extent, also varies the characteristics of the bearing.

The design of a ball bearing is controlled by the size of the ball and the bore; whereas a taper-roller bearing is controlled to a large extent by the size of the rolls, the length of the rolls, the center line of roll angle and by the bore. It does not follow therefore that a series of sizes for ball-bearings can be economically duplicated in taper-roller bearings.

A roller for a taper-roller bearing has a certain shape, the mean diameter being a certain percentage of the roll length, based on the most economical production in consideration of the carrying capacity. The best practice of American motor-driven vehicles indicates that a ball and a taper roller have approximately the same carrying capacity when the length of the roller is approximately equal to the diameter of the ball. The diameter of the roller, however, will be from one-half to two-thirds of its length and as a result a roller bearing for a certain capacity and having a certain bore, would be much smaller in outside diameter than a ball bearing of the same

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capacity and having the same bore. It would, therefore, seem self-evident that our standards based primarily on size interchangeability are commercial in conception and not technically tenable.

Influence of Assembling Practice

The contradiction in assembling practice is even more striking in suggesting inadvisibilities of interchangeability. The underlying principle of the taper-roller bearing is no doubt familiar to all automotive engineers, the basis of design being the cone, as contrasted with the sphere of ball bearings or the cylinder of straight-roller bearings. The bearing surfaces of both inner and outer races are frustra of cones and the rolls are also conical, the dimensions being chosen so that the apices of the three parts coincide on the axis of the bearing and true rolling action results. Ribs are provided on the inner bearing race to prevent the rolls from working out of the large end of the bearing and a cage or roll retainer is used to space the rollers and preserve accurate alignment.

The cup of a taper-roller bearing should have a press fit in stationary housings, such as differential housings, pinion-shaft housings and transmissions; whereas, under the same conditions, the annular ball bearings should have a light fit.

It would seem, therefore, that if bearings of widely varying capacity characteristics were used in interchangeable housings, with perhaps the same means of mounting, one of the two might be at a serious disadvantage through the application of fitting tolerances and details designed for another type of bearing.

Manufacturing Usage and Standardization

Current practice, where based on economically and scientifically sound conception and production, should have much weight in consideration of standards. The primary purpose of this paper is to foster a recognition of usage as more sound than misapplied theory. The largest producer of taper-roller bearings in America now offers a list of over 250 standard sizes, varying in capacity from that necessary to support a motorcycle, to bearings large enough for a 10-ton truck. These are now commercially available and a new set of standards would therefore appear unnecessary and superfluous. If only a small number of sizes were available the designer would have a limited selection. With a given load the designer could, from a larger list, select a bearing providing very closely the capacity desired. With a smaller list he would either have to sacrifice capacity and select a bearing that would be slightly overloaded or sacrifice economy and select a much larger size than was needed for the load involved. Any arguments in support of an extremely limited list would therefore appear to be with a short-sighted view toward manufacturing economy rather than to the broader economy of assembly and compact usage by a large number of customers.

There is a further and most important economy available to the designer through selections from a longer list of available sizes and capacities in taper-roller bearings. It has been pointed out previously that the taper-roller bearing offers a maximum carrying capacity in a minimum compass. It would therefore follow that a given load could be handled with a less expensive bearing, housed in a container of smaller dimensions, in many instances assisting in that most essential effort, reduction of unsprung weight.

The matter of interchangeability in service scarcely needs any explanation. There is no logic in asking the existing producers of widely used equipment to produce another and almost entirely new line of sizes. Their present products have been freely accepted for a great many years. The first duty of a supplier is to his customers. There seems to be no demand upon these suppliers from such customers to add additional tool and equipment investment or to complicate the maintenance of existing vehicles by supplanting sizes employed by them with parts made to other dimensions but offering similar capacities. This would compel thousands of dealers to maintain stocks of two lines of sizes for replacement in cars supplied over a period of years. By the end of 1919 approximately 3,750,000 automotive vehicles will have been produced and put into service, equipped with one make alone of taper-roller bearings, all of sizes selected from existing lists. Many of these vehicle manufacturers carry over their designs from year to year and, since these builders represent much of the best that our industry offers, their opinion of not desiring any change or duplication has carried and will continue to carry weight.

Factors Permitting Progress

Repeated references to current usage should not imply any lack of constant development. In fact, this has recently been illustrated again. As previously shown, the design of the ball bearing is controlled by the bore and the diameter of the balls, whereas a taper-roller bearing is controlled by the bore, the diameter and length of the rolls and the center line of the roll angle. Application of these added functions to a war emergency demonstrated a broad fund of resourcefulness in meeting capacity requirements within a constant compass. The Class B military truck was conceived as a 3-ton design. But, when its work was finished, the committee in charge discovered that each of the sub-committees had designed their component parts with such ample factors of safety, involving such an excess of material, that the machine, with one or two exceptions, could be rated as a 5-ton truck. It might even be considered that it is a 5-ton truck equipped with a more powerful engine and heavier than other 5-ton trucks that have made the use of the motor truck in America so successful and popular.

As originally designed, the Class B truck was equipped with 36-in. wheels and the worm-shaft bearing was selected for a loaded weight of 19,900 lb. and was provided with 40-in. wheels. The original worm-shaft bearing selected on the lesser weight with a smaller wheel diameter was at first loaded to 102 per cent capacity. In the truck as actually built the same bearing was loaded to 135 per cent capacity. When the designs were completed the fixtures for manufacture were either too far along to change or entirely completed. It was therefore essential that an interchangeable bearing of additional capacity be immediately designed and produced to meet unexpected requirements.

The taper-roller bearing manufacturer produced a bearing meeting this emergency and not delaying the production of military vehicles. Seventeen rolls instead of twelve were used in the raceway assembly by employing a new type of cage. The first bearings were tested under extraordinary conditions, such as a 5-ton dead-load on the truck and pulling two loaded trailers. The test trucks operated six weeks under these conditions, running from 6000 to 10,000 miles. The success of these tests was such that types of bearing other than the taper-roller bearing, were excluded from further consideration.

In passing, it might be stated that American partici-

pation in the Great War was hasty and involved some waste, but in the details referred to within the scope of this paper, initial selections were developed permanently and interchangeably with the application of combined talents so unselfishly available. The performance of the bearing mechanism fittingly illustrates the resourcefulness in design and in the application of the functions of taper-roller bearing capacity to meet even the most exceptional conditions. These details need no more explanation than does the dependability of the B truck in its entirety.

We have quoted a British authority as to American accomplishment in automotive apparatus but time permits of only the few hints that I have given of the many proofs of dependability in American equipment. Direct references in this paper are taken from comments of business associates who are qualified to speak for all of us because their products represent the dominant practices in American design. It will be interesting in addition to go behind the scenes to hear from an enemy analyst who is peculiarly neutral in an effort to pick out those Allied products whose duplication should assist Germany in rebuilding her export trade after the war. In conclusion therefore the testimony of this enemy observer during the Great War is thoughtfully submitted as evidence of the usefulness of American bearing equipment and economy, produced to existing standards. This testimony is:

> The life of taper-roller bearings is very long. This has been very clearly demonstrated on captured trucks. They (the bearings) are in almost perfect condition even in cars of the old types, which is remarkable considering the hard service and limited attention during the war condition. This fact has created considerable interest, both in Army and automobile circles, and negotiations are pending for the purpose of manufacturing these bearings in Germany.

Another prominent American engineer, a native of Great Britain with experience there, who was first associated in America with one of our large producers of trucks and passenger cars, and now in another assignment, expresses his preference for the American system of measurement and states his belief that there is no good reason for any change, saying "Stick with inches," particularly with the standardization methods. He compares our system here with the chaotic discussion of alloy steels that is subject to the whims of every purchaser. He associates change from the American system with the confusion here in our various stock grades of alloy steel.

I have a pamphlet here which was written in Berlin two months ago and deals with German industrial conditions. The last paragraph gives some of the views of business men in Germany and states that if Germany gets through the coming winter without another revolution, the period following will see conditions better, the mark worth more, wages lower and production increasing. These developments will be gradual, but Germany will in a few years become a competitor in the machine-tool market of the world.

The Discussion

W. C. Keys:—On the subject of standardization, I know of an instance where proposed standardization does not dovetail in with the largest production of a certain article in this country and yet it is the sense of the men working on this standardization that its adoption will be best for the industry in general.

Mr. Cornell:—If the standardization be along a consistent line that is true, granted that the articles available at the present time are in very general use. Yet when new work is laid out at any time, say within two years after the standardization, any engineer would by preference pick one of the few standardized articles in a consistent series covering all requirements, rather than pick some which do not. The same thing arose in connection with the proposed standardization of bearings a year ago. It was pretty thoroughly discussed with the result that certain standards were adopted but have not been generally used.

A. M. Dean:—I can recall a very learned discussion of some years ago on the question of carrying capacity of ball and roller bearings. At the end the discussion finally got down to the difference in area of a point and a line. Whether the matter has been decided, I am not certain. We have used both types of bearing. Either is satisfactory if applied properly.

E. W. Weaver:—There is such a thing as putting a thing over and yet not being able to make it stick. The American Society of Mechanical Engineers, for instance, a number of years ago thought to bring order out of the chaos existing in the machine-screw situation, by evolving a standard list. It was excellently worked out from a theoretical standpoint and would have been excellent from a practical point of view, if (a) there had not been other existing standards that were too firmly established to be easily set aside, and (b) the A. S. M. E. had had the autocratic power to put the standard into general use.

The Society of Automotive Engineers brought out its line of standardized bolts and had the prestige and the backing in a business way not only to put it over but to make it stick. About a year and a half ago the small machine-screw situation was in much the same state as before the American Society of Mechanical Engineers took hold of it. Military necessity required standardization and in connection with other agencies the Aeronautic Division of the S. A. E. Standards Committee adopted certain standards, based on practical considerations, which will probably be generally accepted.

The paper brings out the fact that the Standards Committee, in working out a list for adoption, gives more weight to the theoretical requirements of the future than to the practical experience of the past. I presume that is a good thing. It helps us correct past mistakes. In this particular subject new sizes are being provided which it is expected will supplant existing commercial standards at some future time. If the existing line covers the requirements, it will be very difficult to eliminate the old sizes in favor of the new, and we will have added to rather than subtracted from the number of sizes of bearings, which, I take it, is the main object of the standardization work.

After we entered the war, the Government authorities, expecting to solve the service question, decided to have all trucks of a given type just exactly alike, and instead of adopting an existing type giving good service, worked up designs of its own. Very likely the designs worked up were better, but the war would have had to run a long time before the results aimed at could have been achieved. Much the same results may be looked for in adopting as standards sizes not now in existence.

L. P. Kalb:—The subject of standardization always raises a question of expediency not only as to the advisability of sacrificing what we have but as to the advantages to be obtained from it. I think it is not necessary in standardization to throw away all we have, but I be-

lieve it is frequently possible, and perhaps in the case of taper-roller bearings, to use as a basis certain of the most common sizes and work up a logical sequence from them.

H. H. NEWSOM:—In general I believe in engineering practice and that engineering principles win out in the end. In establishing standards I think they should be set to the best engineering practice although they do not become effective at the time. They should be striven for and finally arrived at, and regardless of what may or may not happen they will come anyhow of their own weight.

With reference to the metric system, I do not know how long the United States will be in getting on her feet after the war, but I do know that any tampering with our system will create inefficiency. This is no time for inefficiency. We must strive for greater efficiency and increased production. Attempting anything in the way of a change to the metric system would be folly for some years to come.

C. S. PELTON:—It does seem that in some ways the metric system is more convenient to handle than the system we use, but at present this country is in such a bad condition and efficiency in production is so subnormal that anything which would tend to disrupt conditions is very inadvisable. I believe that after the peace treaty is finally signed there will be a greater exchange of products between America and European countries than ever before, and if at some future time there could be a common system of measurement matters would be simplified.

MR. CORNELL:—The suggestion made to work toward a more limited list is good. In fact, of the 250 sizes mentioned less than half are in quantity production at present. Many of the remainder are of necessity kept in supply for replacement. One producer continued an obsolete bearing for seven years. It was not until the design was changed that this part was eliminated.

M. R. WELLS:—The matter of adopting standards of taper-roller bearing sizes should, it seems to me, be considered for an entirely different reason than has been mentioned. Rather than attempt to make the ball bearing interchangeable with the roller bearing it seems they might be considered from two separate standpoints, reducing each type to as small a number of sizes as possible. Any of the men here who have been connected with the supplies of the Army realize what an enormous thing it is to handle spare parts for a large number of different types of vehicle. Reducing the number of bearing sizes to one-quarter or one-half of the prevalent number would mean a great saving.

MR. CORNELL:—The tendency to decrease the number of sizes is right, but it should not be carried to the point of penalizing the customer. If the customer had a spindle of 1¼-in. alloy steel and there was no bearing of that size available, he would have to use a 1⅛ in., which would stress the stock steel beyond its strength and he would have to use a higher priced steel. We propose to provide the maximum carrying capacity in a minimum space.

MR. WELLS:—In England when it came to war, certain truck manufacturers lost out completely because their parts were not interchangeable. The War Department made out its list of interchangeable parts for all makes of truck and those that were not standard were put on the black list. Trucks were scrapped rather than make the attempt to carry repair parts for them.

CHARACTER OF MOTOR TRANSPORT CORPS RECRUITS

THE psychological rating test is being applied by the Motor Transport Corps in the examination of the applicants for the special technical training schools which have recently been placed in operation at Camp Holabird, Baltimore, Md., and Camp Jesup, Atlanta, Ga. Some interesting results have been noted in connection with the examination of 1922 men at the former school who either had expressed a preference for the corps or had enlisted with the intention of taking the special training courses given at these schools. The result of this rating confirmed the belief that a superior class of men were enlisting in the corps.

Of the 1922 men examined 1386 attained higher ratings than the average of all soldiers who took the test during the war and the average rating of the remaining 536 equalled that of all soldiers now being recruited. Only 137 were rated as low psychologically and 51 as semi-illiterate. The 536 men of average recruit mentality were rated as unsatisfactory for special training purposes although they were entirely acceptable for Army vocational training. Four of the recruits had taken a four-year college course and 319 had spent one or more years at high school. Only 191 of the 517 who had had one or more years of elementary schooling failed to go beyond the fourth grade, more than two-thirds having reached the last grade and over half of these had completed the elementary school course. Eighteen of the recruits had spent one or more years at college.

Vol. V December, 1919 No. 6

Load-Carrying Possibilities of Angular-Contact Ball Bearings

By F. C. GOLDSMITH[1] (*Member*)

SEMI-ANNUAL MEETING PAPER *Illustrated with* DIAGRAMS

THE discussion of this paper and the author's reply were not available in time for publication in the September issue of THE JOURNAL with the comments on the other papers presented at the Summer Meeting of the Society. For the convenience of the members a brief abstract of the paper which was printed in the July issue of THE JOURNAL precedes the discussion.

ABSTRACT

BALLS as load-carrying devices date far into antiquity. The use of hardened steel balls in raceways as journal bearings is, however, of recent origin. Only in the last quarter of the nineteenth century were steel balls produced at a reasonable cost and sufficiently accurate in spherical form to be used in journal boxes. Various forms of race members were devised and ball bearings began to be employed to a large extent in industry. These early applications were subjected to very little load and small balls served to perform the functions required. Indeed, it came to be commonly believed by mechanical men that these bearings were suited to carry only the lighest of loads.

In the endeavor to secure the very low friction values present when balls are used in journals, means were devised to test the load-carrying values of the balls themselves, and larger and still larger balls came to be used. The raceways, however, showed little improvement, being merely increased in size without change in material or its treatment.

The author proceeds to analyze the possibilities of the purely American angular-contact or cup-and-cone type of bearing when it is made as accurately as it must be made to utilize to the fullest extent the friction-reducing properties of absolutely round steel spheres confined between accurately generated and ground curved raceways of steels, as highly perfected and as scientifically treated as are the balls themselves. He also determines the load-carrying powers of such bearings and the law of variation of load-carrying capacity in such a bearing, since the direction of the bearing load may vary from the perpendicular to the axis of rotation, or a pure radial load, to coincidence with the axis of rotation, or pure end-thrust.

Formulas for bearings with different numbers of balls and many curves and illustrations are used in making the points outlined. Both the balls and the races are considered as elastic units and the two as one piece of apparatus. The races can approach each other only in the line of action of the single load. Under the heading "Determining Load-Carrying Capacity," Hertz and Stribeck formulas are again used in a mathematical study of the subject. The author refers incidentally to the highly developed and technically studied annular type of ball bearing of German origin.

THE DISCUSSION

K. HEINDLHOFER:—In consideration of the deplorable fact that the application of mathematics to problems of engineering is being more and more neglected, it is doubly gratifying that Mr. Goldsmith has started an investigation of facts that are nothing short of fundamental and of the greatest importance in connection with the theory of combined load-carrying capacity of bearings. There are various points, however, to which I would like to take exception.

One of these is found in the paragraph describing Figs. 1, 2 and 3. The text reads as follows:

> In Fig. 3 the small arrows show how this same load acts with respect to each individual ball . . . and, in Fig. 4 are shown the true angles between the line of ball contact and the line of "load application" for each of the eight balls . . .

It is an axiom of statics that action and reaction at the contact point of two bodies are in the direction of their common radius of curvature, normal to their common tangent at the contact point, assuming that no friction takes place between the bodies. Concerning this friction, it is an established fact that it corresponds to an angle of less than 6 deg. between the polished bearing parts, which is small and may be neglected for our purpose, the same as Mr. Goldsmith has ignored it.

It might be of value to illustrate further the application of this principle referring to the contact forces, as some diagrams in the *American Machinist*, June 26, 1919, page 1234, pertaining to the same subject, are also conducive to error. To elucidate the matter further, let us direct our attention to the following diagrams: Fig. 9 and the dotted position of the body in Fig. 11 are static impossibilities. Fig. 10 and the heavy circle in Fig. 11 show the correct direction of forces.

The left-hand drawing in Fig. 12 represents a case which could exist only with an infinitely great normal load. Great loads will compress bodies in contact and the bodies will resume a position as shown at the right of this illustration. The static forces on a wedge are shown at the left of Fig. 13.

The other portion of this illustration is not a possible distribution of forces, friction excluded. The two latter examples are shown with reference to the example common in elementary textbooks.

Mr. Goldsmith does not seem to build up his equation on the principle of equilibrium by which the resultant of all forces and the sum of static moments of these forces must vanish. On account of this, his equation (28), which is to determine the load P_o on the ball under maximum strain in terms of the angular bearing load P, is fallacious with the exception of the special case $\Theta = 0$, that is pure radial load. In this case the angle $\omega = 0$ and the direction of the "load application" does coincide with the line of contact and this explains why his check coincides with Stribeck's equation. For all other cases, $\omega = \pm 0$ and his formula (28) give incorrect values. This can be proved readily by applying formula (28) to a pure thrust load, in which case

$$\Theta = 90^\circ \cos \Theta = 0, \sin \Theta = 1, \cos (\Theta - \beta) = \sin \beta$$

and formula (28) can then be reduced to

$$P = P_o \left\{ \sin \beta + 2\eta \sin \beta \right\} = P_o (2\eta + 1) \sin \beta$$

[1] Chief engineer, New Departure Mfg. Co., Bristol, Conn.

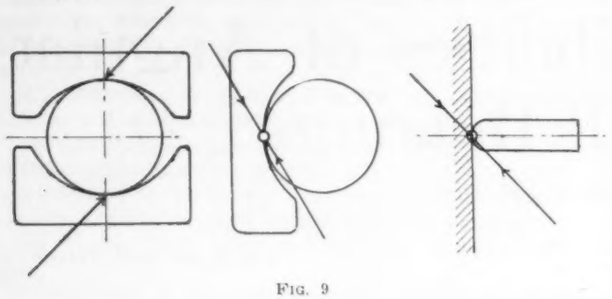


FIG. 9

Considering, however, the fact that everything is symmetrical and the balls uniform, P must be in equilibrium with the force P_o, which occurs η times. P and P_o include an angle of $90° - \beta$. (See Fig. 14). Consequently

$$P = P_o \eta \sin \beta$$

Compared with Mr. Goldsmith's formula, the latter gives less than one-half of the value for P at a given P_o.

In my opinion, the problem of the angular loading of ball bearings is rendered statically indeterminate in an additional respect that seems to have been overlooked by the investigators. The fact is that resistance is offered by the shaft against angular displacement of the inner, relative to the outer, race which involves an additional feature of static indeterminacy. Two extreme cases may be imagined.

(1) The shaft and mounting being absolutely stiff against angular displacement of the inner race, due to elastic deformation at the contact points
(2) The shaft being absolutely flexible

The actual conditions will be found between the two, and a solution of the problem in both cases will give a good idea of the actual maximum ball load.

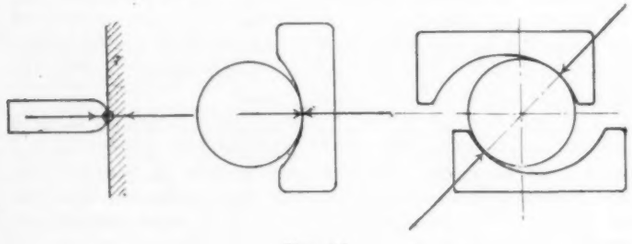


FIG. 10

The condition described under (2) has been investigated experimentally by A. Palmgren (see *Teknisk Tidskrift*, April 9, 1919), and I think that it would further the interests of engineering and the ball-bearing industry if the case described under (1) were investigated in the near future, especially if a general formula be developed to cover all cases.

E. Z. JAUSZ:—The efforts of Mr. Goldsmith to solve this important problem in a mathematical way are without doubt very commendable. If, however, the results brought out are incorrect, unfortunately or fortunately, no matter how worthy of praise the effort, the author of the article should not be immune from criticism. In the interest of the whole bearing industry I wish to call Mr. Goldsmith's attention, as well as that of every engineer interested in this problem, to the following statement with reference to Fig. 4. "From an inspection of these angles one can readily see that, for this particular load, balls 4, 5 and 6, do not carry any of the load."

From an inspection of the angles referred to the only thing one can readily see is that the angles ω_4 and $_6$ and ω_5 are larger than 90 deg. In other words, it is claimed that if these supplementary angles are larger than 90 deg., the respective balls do not take part in carrying the load. This contention is erroneous and, in fact, in case the bearing is loaded as depicted in Figs. 1 to 4, the balls 4, 5 and 6, in contradiction to the above cited statement, will take a certain amount of the load when we consider "that the balls as well as the races are elastic bodies"; but manufacturing inaccuracies and non-uniform elasticity of material are, of course, excluded.

To prove this, let us assume the simple form of supporting a wedge on two balls (see Fig. 15), the section of an idealized cup-and-cone bearing with a load acting on the wedge. This support is obviously able to carry

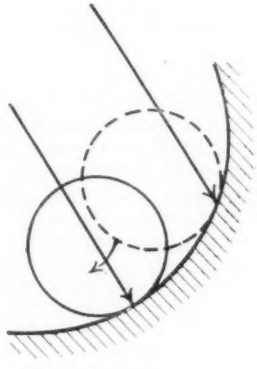


FIG. 11

P as long as P and the two supporting points are in one and the same plane and P passes through point A. According to Mr. Goldsmith's statement, ball 2 would not carry any of the load or else this special case is an exception to his general rule. The components P_o and S, in Fig. 15, represent the loads carried by the respective balls. From this simple form of support it can be seen that the passing of the 90-deg. line X-A is not the neutral line, where a particular ball ceases to take part in carrying out the 180-deg. line Z-A. This holds good for bearings with any number of balls, with the single modification that the "zone of possible action" is not a segment, as shown in Fig. 15 by the angle a, but is a pyramid of as many sides as there are balls in the bearing, or a cone with a bearing of an infinite number of balls. Immediately the load is outside of this zone of possible action, or when the load or its line of application does not pass

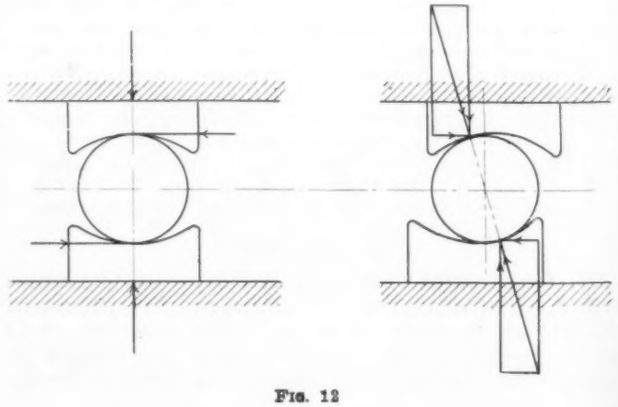


FIG. 12

through the point of the cone, pyramid or segment, the bearing ceases to be a unit in itself.

In Fig. 1 of Mr. Goldsmith's paper the load is represented as passing through point P, which would result in a twisting moment on the shaft that cannot be resisted in the bearing shown and requires the employment of an additional bearing. But this moment also has an influence on the load distribution in the bearing, and thus the distance between the two bearings also comes into play, or at least it should, in our consideration. (See Fig. 17).

In the case of a pure radial-bearing, as illustrated in Fig. 16, angles b and $\theta = 0$ and $a = 180$ deg.; the zone of possible action is thus a plane and hence this bearing can carry in itself only loads acting in this plane, friction neglected. The other extreme is shown in the same illustration, a pure thrust-bearing with flat races. Here $b = 90$ deg., $a = 0$, and the cone or pyramid is a cylinder and a column respectively, where the point of the cone is a surface equal to the one circumscribed by the ball pitch-circle or pitch-polygon. Even in case Mr. Goldsmith has assumed an absolutely stiff and infinitely long shaft, which assumption would make possible only parallel motion with the shaft axis and reduce the moment reaction, since P does not reduce at A to zero, the effect of the contact angle is still there to be taken into consideration. The lower balls, so to speak, will roll upward on the slope, because φ does not equal b, carrying the inner race with them until a resistance is found in the upper balls, No. 2 in our case and Nos. 4, 5 and 6,

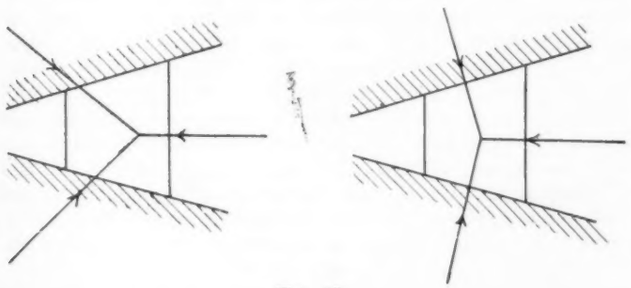


FIG. 13

in Mr. Goldsmith's case. This condition cannot be neglected. In the case of a grooved ball-race, this rolling upward on the slope would either last until resistance is found in the upper balls or until angle b reaches the magnitude of angle φ. Radial bearings with grooved ball-races join the class of cup-and-cone bearings immediately when the load is applied at an angle to the plane of possible action, and if the load line passes through the point of the cone.

The question brought up by Mr. Goldsmith is far from being as simple as it is generally assumed to be, especially if we, among other things, attempt to take into consideration the changing with the load, due to elasticity of material only in the bearing itself, of the "contact angle" in the generally used types of ball bearings with grooved ball races.

Mr. Goldsmith's mathematical deductions being based on a fallacious assumption, the resulting formulas and curves are naturally valueless, and so is his article except to the extent that it will probably bring up for discussion an important question and lead eventually to the ultimate solving of the problem. However, it is well to realize that a great many steps have yet to be taken before the goal can be reached.

I wish also to take exception to one other statement of Mr. Goldsmith, that when we think that the balls as well

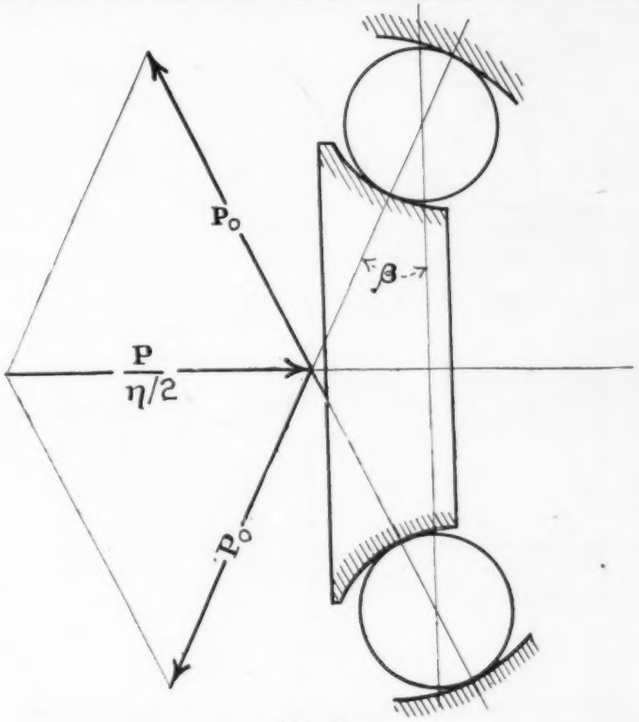


FIG. 14

as the races are elastic bodies, we realize at once that if we consider the actual load as divided into two component loads, one a pure radial load and the other a pure thrust load, we are working under a false premise, for the races can approach each other only in the line of action of the single load.

We are certainly always working on a sound premise when we work with the components of a force, as long as we do the resolving and our consequent reasoning properly and carefully, and especially so in this particular case. I think that this last statement does not need any

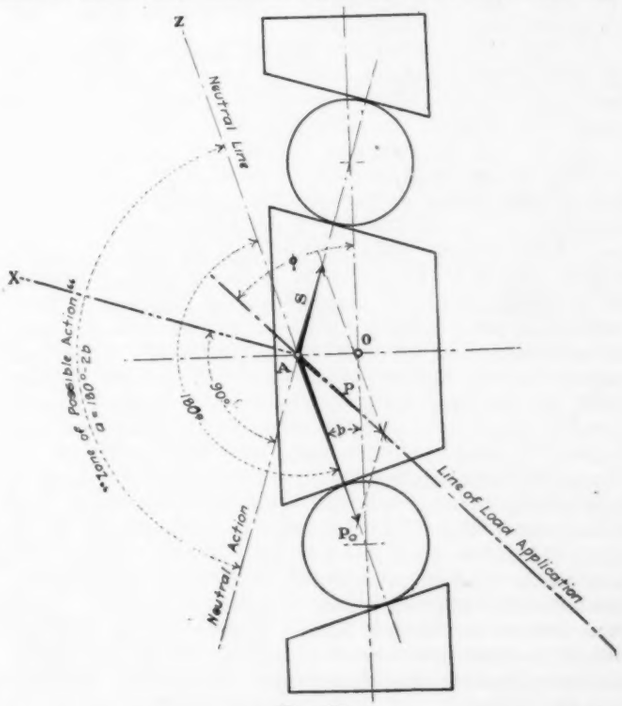


FIG. 15

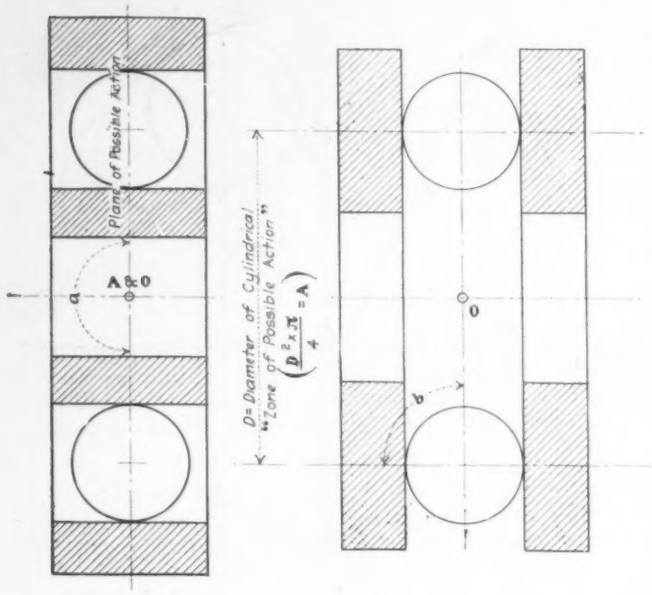


FIG. 16

proof, for the same reason that it is idle to prove that two plus two equals four.

MR. GOLDSMITH:—The comments of Messrs. Heindlhofer and Jausz have proved very interesting indeed. I regret very much that I did not have the article printed according to the original draft which, although lengthy, was very thorough. I am sure that if I had done so, these gentlemen would have been better able to follow the reasoning. After having studied all the comments which, by the way, were not altogether new to me, I still maintain that the reasoning in the original article is correct. Both Messrs. Heindlhofer and Jausz make several points in their comments that I am unable to understand, and I am sure there are others who would like these points explained more thoroughly.

In Fig. 18 I have endeavored to show all the practical mountings for the angular-contact type of bearing. All the bearings shown in the drawing are of the same size and kind. The bearing shown is what is known as a No. 307 S. A. E. Medium Series, 100 per cent angular-contact bearing, so designed as to carry approximately the same load in pure thrust as the so-called pure radial load. The bearings, as well as the shafts, are drawn exactly to scale and show relative sizes of bearings as well as shafts. Under (*a*) and (*b*), we have a combination mounting of a radial and an angular-contact bearing. These mountings are generally used where there is thrust only, or where the radial load is comparatively light with respect to the thrust. The question probably arises, "Why not use a pure thrust bearing?" Because where speed is required a pure thrust bearing cannot be used. Under (*c*) and (*d*), we have the two most common mountings, the bearings being used in pairs opposed to each other; (*c*) shows a mounting where the cones must be adjusted, while (*d*) calls for an adjustment of the cups. In either of these mountings a pure thrust load, or a radial load in combination with a thrust load, can be carried in either direction. Under (*e*) and (*f*), I have shown what are termed duplex mountings, in combination with single-row annular bearings. The only difference between these two mountings is in the way the bearings are adjusted; (*e*) shows a cup adjustment, while (*f*) calls for a cone adjustment. This duplex mounting is excellent, being capable of withstanding heavy radial loads in combination with thrust loads in either direction. This mounting is meeting with good success as a high-speed grinding-spindle mounting. I have known of its successful operation at speeds of about 21,000 r.p.m. Another excellent mounting, but a rather expensive one, is a combination of two duplex mountings, one being constructed so that it floats in the housing and takes only the radial load.

Before taking up my final line of reasoning, there are two or three points raised by the gentlemen that I wish to eliminate. They have no practical value to engineers at large. First, I wish to ask just what an absolutely flexible shaft is, and what practical value it has in connection with ball-bearing mountings? Second, do either of the gentlemen imagine that I built my entire line of reasoning on the assumption that one of these bearings would be used to carry the load by itself? Third, both gentlemen mention friction in ball bearings, Mr. Heindlhofer in particular, mentioning a 6-deg. friction angle. A ball bearing is usually called an anti-friction bearing, and it is generally conceded that a steel ball is the one object that will carry a reasonably heavy load and roll in any direction with the least amount of applied force. I have my own conception of friction in connection with ball bearings and would surely like to hear more in detail on this subject. I might say that a 6-deg. friction angle is about correct for two well-lubricated, flat, polished steel plates pressed together; but surely Mr. Heindlhofer would not have us consider a ball and its raceway in the same class with two plat steel plates. Fourth, I quote Mr. Jausz, "But even in case Mr. Goldsmith has assumed in his paper an absolutely stiff and infinitely long shaft," which I was not aware I had assumed; and Mr. Heindlhofer, "The actual conditions will be found between the two and a solution of the problem in both cases would give a good idea of the actual maximum ball load." I would like to make clear that I fully realize that a shaft must deflect, but the deflection is generally very slight and can be interpreted in connection with the use of the *K* curve, as in Fig. 8. The task of the ball-bearing engineer is to consider each problem as an individual case and, in choosing the proper

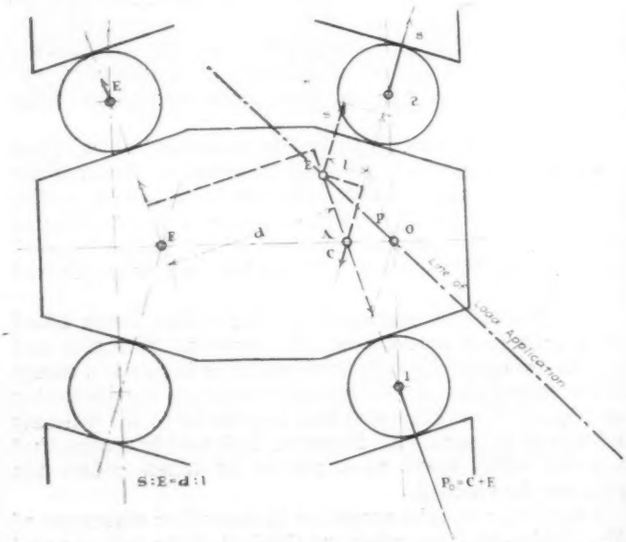


FIG. 17

kind and size of bearing, to insist upon the essential features necessary to the successful operation of the bearings.

To obtain some idea of the amount of this deflection, I stated at the beginning of this reply that the drawings in Fig. 18 were made exactly to scale. After looking at this illustration can you conceive much of a deflection? From actual calculations, assuming a bearing spacing of 24 in. and a maximum combined radial capacity of both bearings applied midway between the bearings and a machinery-steel shaft, the actual deflection would come within less than 30 min., or ½ deg.

Answering the last three paragraphs of Mr. Jausz' criticism, I agree with him that two plus two makes four, but after carefully looking over his Figs. 15 and 17 it appears that he is trying to make us believe that six plus five is four. In both of these figures Mr. Jausz has failed to consider a fundamental axiom of statics, that when two bodies are in contact action and reaction must be

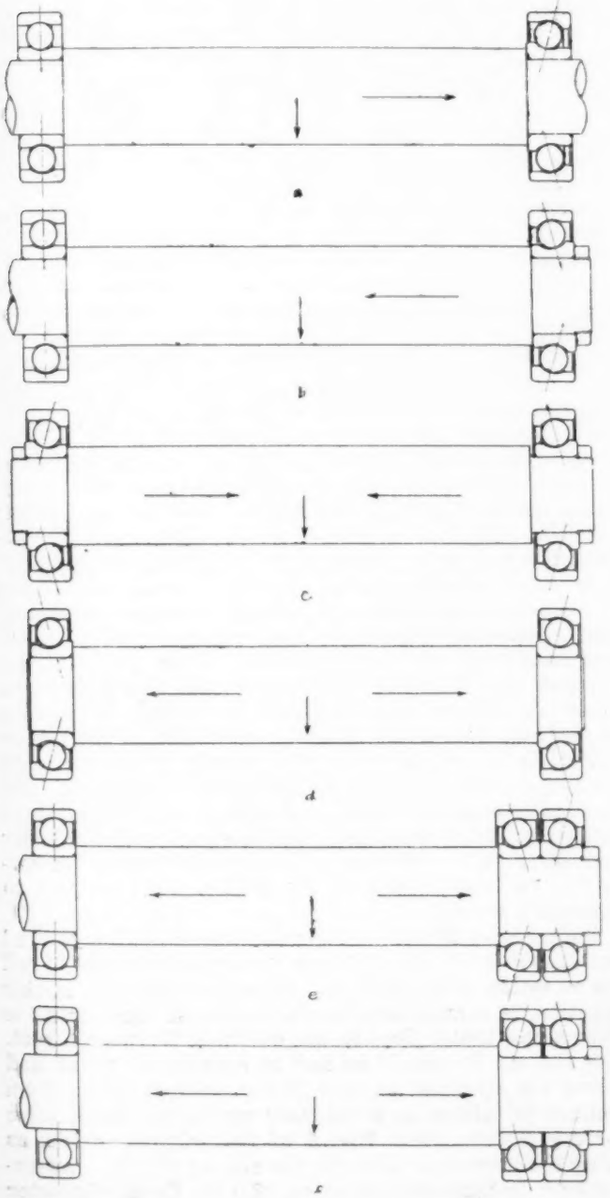


FIG. 18

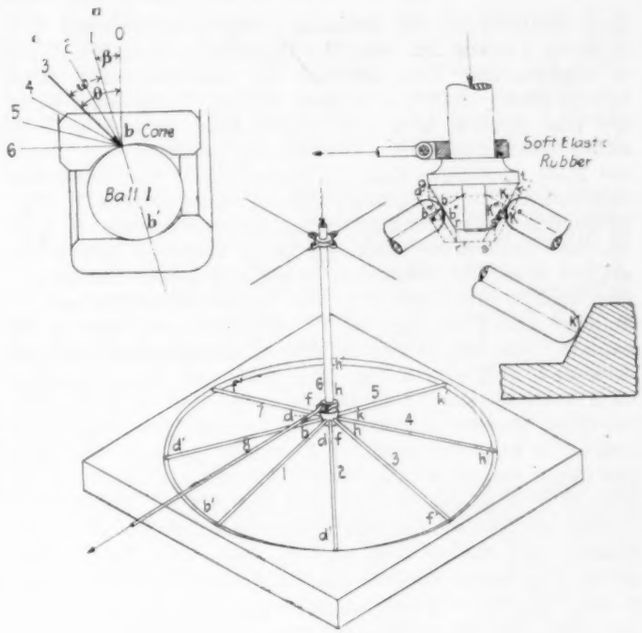


FIG. 19

considered as acting at their common point of contact. In this particular case the action and reaction would be in the direction of the common radius of curvature of the ball and race. Mr. Jausz has built his reasoning about a case of unstable equilibrium. What would keep the wedge from moving sidewise? He has erred also in failing to consider that all the balls under load in the bearing must be considered as acting collectively in maintaining equilibrium. In studying each ball, the line of load application must be considered as acting at the point of contact between the ball and cone. In Fig. 19 at the left is shown how the line of ball-action acts with respect to ball 1, as the angle of load application shifts over 90 deg.; please bear in mind that equilibrium is maintained by the other balls which are under load. In the original article Figs. 1 and 2 were used in only a general descriptive way, while the entire proof was built around Figs. 3, 4, 5, 6 and 7. Quoting from the original article

> Fig. 3 is a side elevation and end view of a bearing containing eight balls, but the mathematical proof to follow considers any number of balls. The lettered arrows show the direction of the applied load as well as the direction of approach of the races with respect to the individual balls, the angle between consecutive balls being shown as α. In Fig. 3 the small arrows show how this same load acts with respect to each individual ball.

I thought I had made clear how the load must be considered as acting with respect to each ball that was under any portion of the total load. Fig. 4 shows an actual development of the angles between the line of ball contact and the line of load application, for each of the eight balls, when the line of load application makes an angle Θ with the plane of ball contact with the cone; or, in other words, when the line of load application acts in the direction as shown by arrow No. 3, in Fig. 19.

If the gentlemen have failed to understand Figs. 3 and 4, they have undoubtedly failed to analyze Figs. 5, 6 and 7, which depict clearly the individual loading of each ball and the effect of the infinitesmal approach of the two races in the direction of the load application, when the condition of elasticity is considered. To clear up this point I have shown in Fig. 19 at the right a very elemen-

tary analysis of the problem. Before explaining this drawing I would ask both Mr. Heindlhofer and Mr. Jausz to explain how they account for the transition from approximately half the number of balls under load, when the load applied is a pure radial load, to all the balls under what is strictly a thrust load? Surely they would not have us believe that the transition is instantaneous, and that all the balls jump suddenly under the load? Fig. 19 depicts the bearing mounting, as shown under *a*, Fig. 18, but, as will be explained later, the same reasoning applies to all the mountings as well. I assure the gentlemen that it even applies to the duplex mountings shown under *e* and *f* in Fig. 18. I shall make no attempt to explain these last two cases, the reasoning being long and difficult to follow. In Fig. 19 is shown an isometric view of a vertical post or shaft, the lower end of which has mounted thereon a soft, elastic, rubber frustrum of a cone. To keep the shaft in a vertical position, we have the upper end shown as passed through a ring, which in turn is held in position by four guy wires. The rubber conical surface of the upright rests as shown on eight round-ended spokes, the axis of each spoke being perpendicular to an element of the conical surface of the

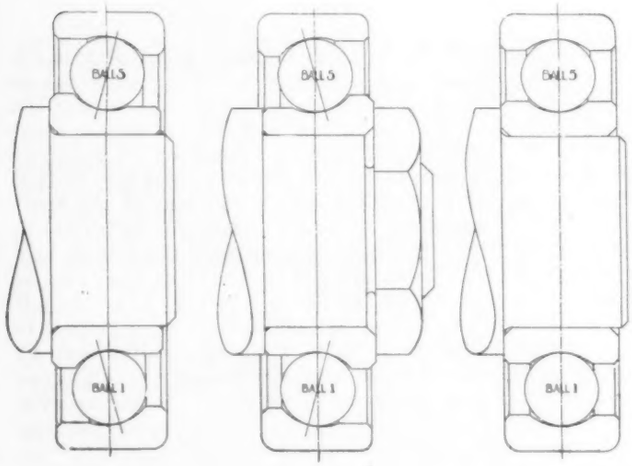


FIG. 20

rubber cone, as well as an element of the conical surface of the outer retaining ring, and each spoke makes an angle with the plane of contact of spokes and rubber cone, or spokes and outer conical retaining ring. To simplify the reasoning, let us first consider all parts as inelastic and incapable of bending or deforming, with the one exception of the rubber conical frustrum. Let us consider that there is just barely enough thrust present to keep the spokes in place; then apply an additional pure axial thrust. Points *b* and *k*, points on the rubber cone-frustrum, will move downward to positions *b''* and *k''*. The upper points of all spokes will have imbedded themselves an equal amount in the surface of the rubber frustrum. Not changing the direction or magnitude of the thrust load, let us now apply a gradually increasing radial-load and see what happens. The points *b''* and *k''* will move over to the left a fixed distance for each radial-load and, when the original point *k* has moved over to the point *k'''* and lies just to the left of the line *ts*, the upper end of the right-hand spoke No. 5 will no longer be in contact with the rubber cone and the spoke will immediately fall. This is the condition in the original article, where the last ball does not carry any of the load or when the thrust angle $\Theta = (90 - \beta)$ deg. Going a step further, allowing the radial load to continue increasing, spokes Nos. 4 and 6 will next drop of their own weight. This dropping out of spokes, in the case of an infinite number of spokes, would continue and approach as a limit one-half the number of original spokes. Second, let us consider the upright shaft as deflecting slightly as the radial load increases. This will only cause spoke No. 5 to drop with a slightly less radial load.

I believe I am correct when I make the statement that many of our fundamental laws of physics and mechanics hold good only under certain prescribed conditions, but, nevertheless, these same laws have untold value to the engineering fraternity at large and more especially to the practical engineer who is capable of applying good judgment and sound reasoning thereto. The practical engineer takes these laws as they are given and arrives at his answers in accordance with each of his particular problems; he is usually not in the habit of swallowing an elephant and straining at a gnat.

I wish to ask Mr. Heindlhofer, and more particularly Mr. Jausz, if they have considered what would happen to Stribeck's proof of the fundamental loading of annular or radial ball bearings, for either flat or cupped raceway cross-sections, if they were to apply their theories of shaft deflection. For, if they are correct, what holds good in the case of an angular-contact bearing certainly holds good to a much more marked extent in pure annular or radial bearings. In Fig. 20 I have shown two identical 100 per cent angular-contact bearings with a 15-deg. contact angle and one radial bearing of the same size and series; regarding general dimensions, ball-center circle, number and size of balls and raceway curvature, they are identical. As far as comparison of the so-called catalog radial values is concerned, the angular-contact bearing has only 96.59 per cent of the radial capacity of the radial bearing, the cosine of the contact angle. Therefore, to begin with, if the two kinds of bearing are loaded in pairs under exactly similar conditions as to their maximum radial capacities, the applied load acting midway between each two bearings, we can, theoretically, consider a larger deflection of shaft in the case of the radial than of the angular-contact bearing. Again, considering both kinds of bearing with exactly the same amount of shaft deflection, the shaft being considered as extended and loaded on the left-hand side, if we pass a plane through the theoretical ball-centers we find there is a clearance between the balls, cups and cones, in the case of the angular-contact bearings, that will permit a very slight rocking of the cone with respect to the cup with no serious effects; while in the radial bearing we have no clearance in this plane and, with a very slight shaft deflection, we would expect a pinching of both the upper and lower balls. Therefore, if these gentlemen are correct in their criticisms of my article, what happens to Stribeck's proof?

I agree with Mr. Heindlhofer's mathematical proof and equation $P = P_o\ (2\eta + 1)\ \sin\beta$; but I would like to call his attention to the fact that the value $(2\eta + 1)$, in this equation, is a mathematical factor which represents the same thing that η does in his equation for pure thrust, $P = P_o\eta\ \sin\beta$; and if he had so considered it and had solved his equation using a 15-deg. contact angle, I am inclined to believe he would have recognized the K value for $\Theta = 90$ deg., from Fig. 8 of the original article, as being the numerical value for the sine of 15 deg. Referring back to Stribeck's equation (2), the Greek character η does not represent the total number of balls. The Eng-

lish italic n, which does represent the total number of balls, is the same as the character η_1 in Mr. Heindlhofer's equation $P = P_o \eta_1 \sin \beta$; and the factor $(2\eta_1 + 1)$ in Mr. Heindlhofer's equation $P = P_o (2\eta_1 + 1) \sin \beta$.

As a matter of fact, I believe it impossible to think of having an angular-contact bearing carrying a pure radial load; for even if the only load acting on the shaft is a radial load, the fact that the ball makes contact with the cup and cone at an angle, will produce a thrust load. Another interesting mounting of these bearings in opposed pairs, which is often misinterpreted, is where either the cup or cone is set up with an initial tension. The designer often asks the ball-bearing engineer how the bearing can carry any radial or thrust load if the initial adjustment should happen to be almost the bearing's thrust capacity at the given speed. Under these very conditions it is entirely possible to carry either a heavy radial or thrust load, or a combined radial and thrust load. I have a very interesting mathematical proof for this condition which I do not choose to print; at least not at this time. Suffice it to say that it is a transfer of loads, similar to that met with in cylinder-head bolts on engine cylinders.

In closing this rather lengthy reply I wish to thank both Mr. Heindlhofer and Mr. Jausz for their criticisms, for in answering them I have only convinced myself, if not others, that equation (28) and the curve in Fig. 8, are a correct solution of this problem, and that when made use of by practical engineers they should at least be of a small amount of practical value.

OBITUARIES

FRANK W. BACON was killed Nov. 27, 1919. At the time of his death Mr. Bacon was driving to Washington to take Thanksgiving dinner with his married daughter. He lost control of his automobile as the result of an old break in the steering rod and plunged 150 ft. down an almost perpendicular embankment on Martins Mountain, near Cumberland, Md. He was born at Warsaw, Ky., Jan. 6, 1867, and received part of his education in the schools there. When a young man he went to Omaha, Neb., and later became president and general manager of the Drummond Motor Co. In September, 1918, he disposed of his Omaha interests and founded the Bacon Motor Corporation, an automobile assembling organization, at New Castle, Pa., and was elected president and general manager. The corporation acquired an existing factory, converted it into an assembling plant and also made certain automobile parts. Mr. Bacon is survived by his widow, who was in the car but was not seriously injured, and by a married daughter. He was elected to Associate Member grade in the Society, March 14, 1917.

J. B. MCCARTHY was killed Nov. 22, 1919, by a cave-in on the large farm which he owned at Birmingham, Mich. He was born Jan. 18, 1868, at Ottawa, Canada, and eventually became a citizen of the United States. Mr. McCarthy received a technical education and from 1885 to 1895 he was chief of power installation work for the Brush Electric Co. In 1895 he became chief electrical inspector for the city of Detroit, holding this position until 1905. He then undertook the publishing of a technical magazine devoted to practical electricity and as president of the business continued this activity until 1914. At this time Mr. McCarthy disposed of his publishing interests and became the wiring materials engineer for the National Metal Molding Co., Ambridge, Pa., which continued to be his business connection until his death. Mr. McCarthy was the inventor of numerous electrical specialties that were distributed by the National Metal Molding Co., and had devised some radical improvements for this company that were about to become operative at the time of his death. His farming activities were a side interest. He was elected to Member grade in the Society, April 12, 1919.

AIR SERVICES IN FOREIGN LANDS

A REPORT of the British Department of Civil Aviation shows that 21,000 flights have been made and 52,000 passengers carried since the official opening of the service in Great Britain last May. These flights were made with practically no mishaps, the number of accidents being only 13, or about 0.062 per cent. It is expected that a fast mail service between London, Paris, Brussels and Amsterdam will be inaugurated shortly.

President Menocal of Cuba has approved the creation of an extensive airport at Havana, the Government having appropriated land for that purpose. This will meet the increasing demand for facilities for large transatlantic and transpacific airplanes and for aircraft flying between the United States and South and Central America. An international aeronautic exposition will be held at Havana, Feb. 21 to March 3, 1920. Complete aircraft of all kinds will be exhibited as well as engines and other accessories. Exhibitions of flying and air races will be held in connection with the exposition. Interest in aeronautics in Cuba is very marked and it is hoped that the exposition will arouse interest in the various countries of Latin America. Plans are under consideration at the present time for the establishment of aerial passenger service between the different Cuban cities.

The Swiss Government is creating an aerial fleet. An annual credit of 1,300,000 francs for the service has been voted by the Swiss Confederation.

Vol. V December, 1919 No. 6

Aluminum Piston Design

By E. G. Gunn[1] (*Member*)

Annual Meeting Paper *Illustrated with* Drawings

THERE is such a wide difference of opinion concerning the fundamental theories that we may expect and do find a great difference in the design of pistons now used in internal-combustion engines. We find long pistons, short pistons, some with the piston-pin near the top, some with the piston-pin near the bottom, thick heads with cooling ribs and thin heads with no ribs.

From a thermal standpoint aluminum pistons may be broadly divided into two classes:

(1) Those designed with the object of conducting the heat away from the head into the skirt and thence into the cylinder walls
(2) Those designed with the object of partly insulating the skirt from the heat of the piston head

Those in the first class are usually more or less conventional in design except that they have thicker walls, or ribs extending down from the head. They are generally used for high-duty engines. In these engines, which are usually of a rather large bore and comparatively low speed, the weight of the piston is secondary to its ability to keep the head from overheating, and piston slaps are not of much consequence. Therefore, for heavy-duty engines pistons of the first type seem logical. A sketch of some of the types which come under the first group are given in Figs. 1, 2 and 3.

Passenger-Car Engines

For passenger-car engines the conditions are somewhat different. The duty is lighter and the bore usually smaller. This lessens the tendency toward excessive heat. Quietness being important, close-fitting pistons are desirable. Need for good accelerating ability and smoothness in operation makes lightness desirable. These considerations have led to much development work on pistons of the second type. The plan followed in most cases is to partially insulate the skirt from the piston head, thus minimizing the expansion of the skirt due to heat. Some of the ways of accomplishing this are shown in Figs. 4 to 11, inclusive.

Pistons of the Long and the Franquist types are split to allow the piston to spring. They can for this reason be fitted more closely than the more conventional types. The conventional type with the comparatively thin wall is probably the most popular and for the smaller bores serves very well. It is simpler and somewhat cheaper to make than other types. In all the other types shown there has been an attempt to insulate the skirt from the head. This allows the piston to be fitted more closely, thus minimizing piston slaps.

Four points are often brought up as objections to the use of aluminum pistons. These objections are the same as those encountered in the use of cast-iron pistons.

(1) Wear
(2) Piston slaps
(3) Excessive oil consumption
(4) Crankcase dilution

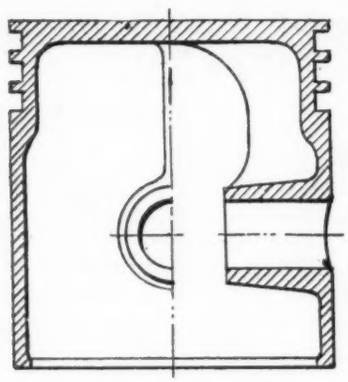
[1]Engineer, Packard Motor Car Co., Detroit, Mich.

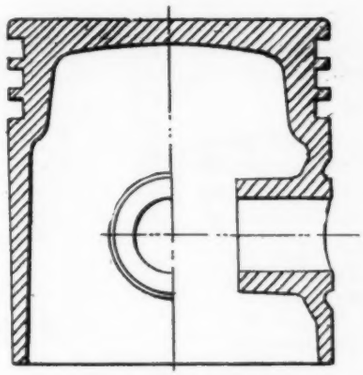
Wear has been shown to be largely a function of original smoothness. It is unreasonable to expect long life when aluminum pistons are fitted to cylinders of relatively hard material having a rough bore. Aluminum has been shown to be a good bearing metal, but it must run on a smooth surface, as in the case of babbitt metal. Much attention is paid to polishing the journals of a crankshaft, but we often see cylinder bores, whether ground or reamed, which are so rough that they can be marked with a lead pencil, although they may appear to be smooth. This is undoubtedly the cause of a great deal of initial wear on aluminum pistons. When cast-iron pistons are fitted this is not so apparent. Dust in the air also plays a very important part in wear. Engines run on the dynamometer give much longer service than engines in cars.

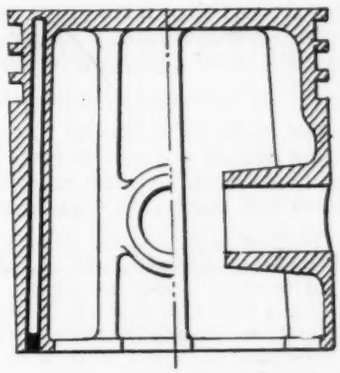
I have lately examined a truck piston with the top ring worn nearly in two, and with over 1/32-in. side clearance. The rings and piston were both polished and showed no sign of scoring. This same model has repeatedly stood the same number of hours' running on test with wear so slight as to be hardly measurable. There is no question that an efficient air-cleaning device would greatly prolong piston and cylinder life.

Piston Slaps

Piston slaps can be overcome by using proper clearance. Pistons of the second design tend to make this condition easier to meet. Offsetting the piston-pin also tends to reduce piston slap. With 3½-in. and smaller bores there should be no trouble due to sticking with pistons of the conventional design fitted closely enough to prevent slaps, provided the piston and cylinder are of proper design. There should be no local hot-spots, and care should be taken in the design to prevent a condition tending to warp the cylinder when heated. Much trouble was experienced with sticking aluminum pistons in a certain inserted-sleeve engine of about 3½-in. bore. The cylinder was in the form of a block aluminum casting, with inserted cast-iron sleeves. Clearances up to 1/64 in. were tried, but still the pistons seized. The sleeves were removed and found to be machined so that there was an air-gap of 0.005 in. between the sleeve and the cylinder wall. These sleeves were replaced with others which fitted all the way down, and pistons with 0.007-in. clearance were then found to be satisfactory. This is perhaps an exaggerated case, but shows the bad effect of failure to carry the heat away from the cylinder bore rapidly. The top land of the piston must, of course, be given much more clearance than any other part. The next land requires less, and the least clearance can be given to the bottom of the skirt. The tapering necessarily increases rapidly as the top of the piston is approached. When the piston-pin is placed too near the rings, piston slaps are more frequent, for the clearance in the zone near the piston-pin bosses must be sufficient to take care of extreme heat conditions so that under ordinary running conditions this part of the piston has enough clearance to allow piston slaps. When the pin is placed farther







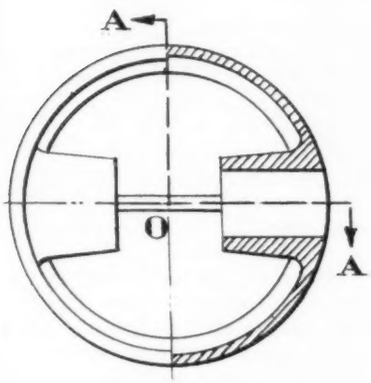


FIG. 1

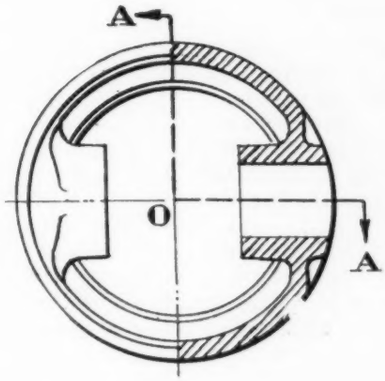


FIG. 2

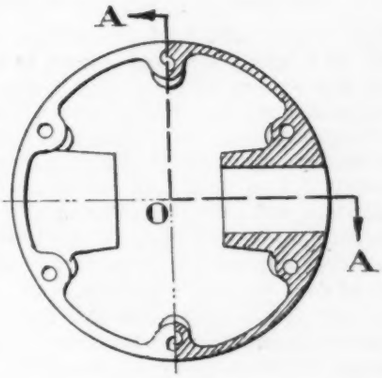
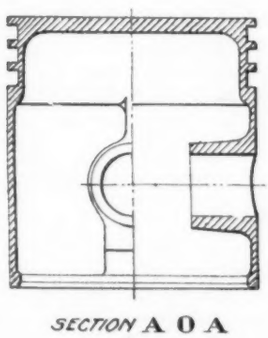
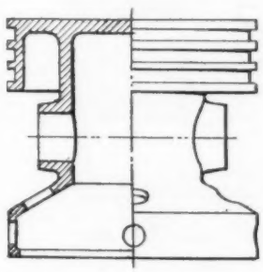


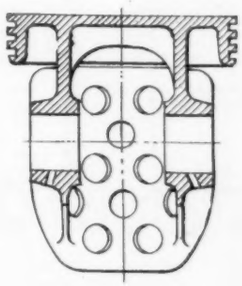
FIG. 3

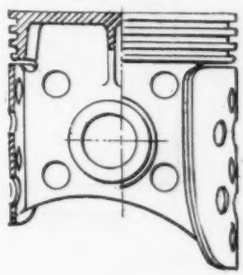
from the head the clearance can be small enough to prevent slaps.

Some trouble has also been encountered due to fitting pins tightly in the piston. When a piston with a tight pin is heated, it expands and creeps out on the pin; when it contracts again, it hangs to the pin so that the piston has a greater diameter parallel to the pin and a smaller diameter at right angles to it. This condition makes









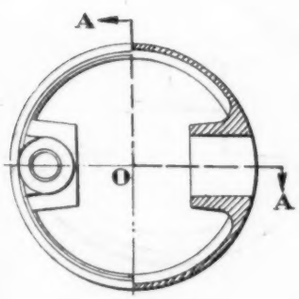


FIG. 4

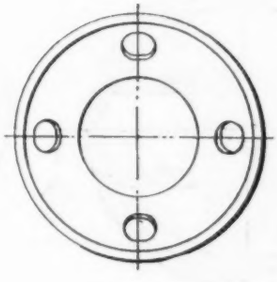


FIG. 5

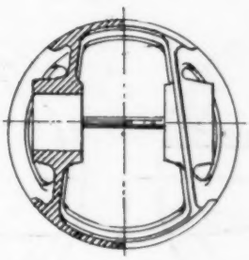


FIG. 6

seizing easier and slaps more pronounced. This creeping can be demonstrated readily by applying a blow-torch flame to the head of a piston fitted with a tight pin.

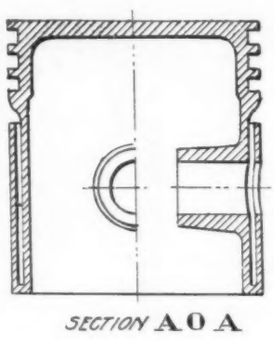
Excessive Oil Consumption

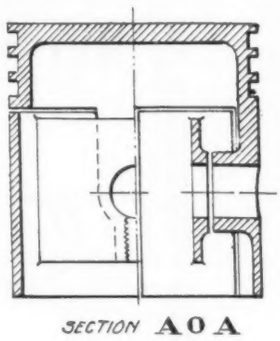
When too much oil is thrown into the cylinder bores, tight-fitting pistons and special rings will not completely overcome the trouble. A great many tests have been run which show this conclusively, demonstrating that:

(1) With no control on the oil being thrown into the cylinder, rings which seal the top and bottom edge of the groove reduced the oil consumption
(2) When the oil is properly controlled, the oil consumption is very low even with rings having an up-and-down clearance of 0.004 in.
(3) With the oil controlled and with hot water circulated through the engine, the volume of liquid in the oil-pan increased, indicating dilution with fuel which passed the piston and rings. This was independent of the kind of rings used

The engine was next run with a device arranged to heat the mixture to a temperature of about 160 deg. fahr. This was accomplished in such a way that the maximum amount of heat was applied when idling. The effect upon fuel vaporization was observed through a glass window and was clearly evident. The result was to diminish the amount of fuel in the oil-pan when idling, and the viscosity was not seriously affected.

Before the installation of the heating device a black deposit was found on spark-plugs taken from the cylinders of cars on road test even when the oil consumption was very low. After the installation, the spark-plugs remained clean under all conditions. It has been common practice for a number of years to put a quantity of kerosene in the crankcase oil, when running-in an engine to allow the bearing parts to seat more quickly. It is fair to expect that crankcase dilution has the same effect and that more rapid wear follows; hence the need for minimizing crankcase oil dilution with unburned fuel.





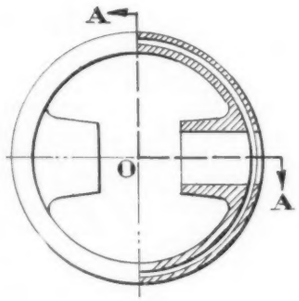


Fig. 7

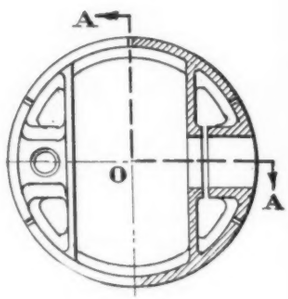
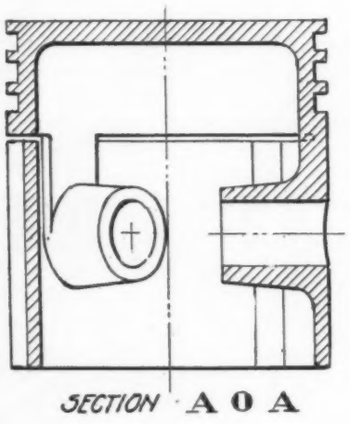
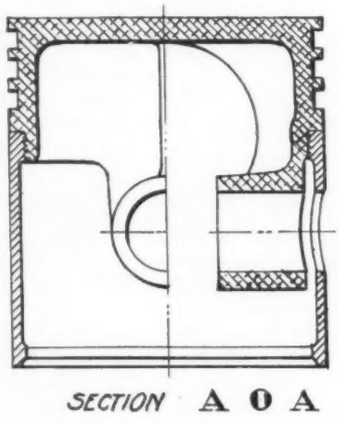
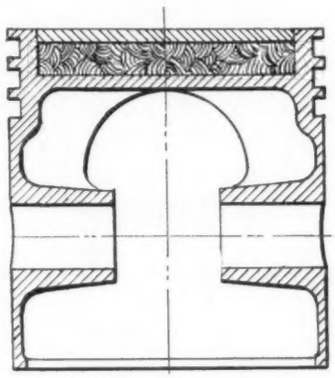


Fig. 8







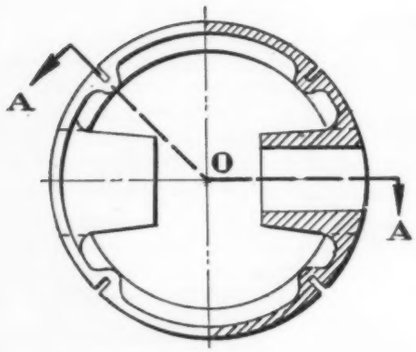


Fig. 9

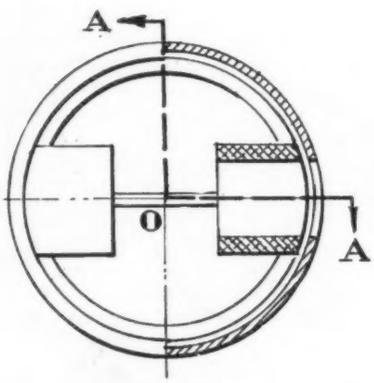


Fig. 10

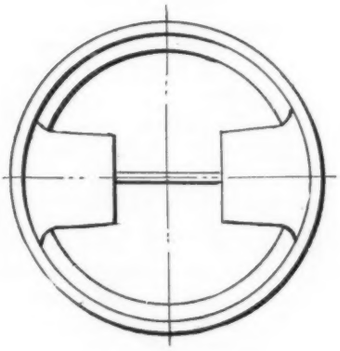


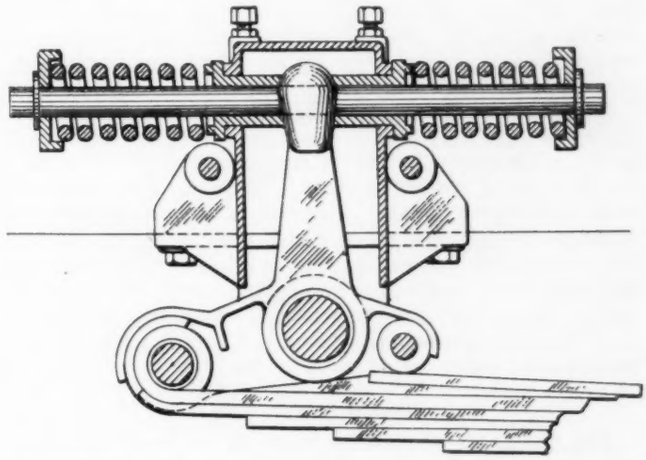
Fig. 11

The Ralls Spring Suspension for Vehicles

IT will be realized, after very little consideration of the design of the normal type of semi-elliptic spring, which is almost universally employed for motor vehicles, that it can satisfactorily absorb only those shocks which take effect solely in a vertical direction. Horizontal blows and the horizontal components of forces other than vertical must be otherwise accounted for. The pneumatic tire is capable of performing some of this service; the solid tire on a vehicle running at speeds of over 5 or 6 m.p.h. is not sufficiently rapid in its action to do so. The consequence is that the solid-tire vehicle with normal springing receives, almost uncushioned, all the horizontal blows as well as the horizontal component of every shock which the wheels suffer.

The solution, obviously, is to provide some springing element which will counteract these shocks and relieve the chassis and its mechanism from this unnecessary and harmful hammering. Occasional and tentative attempts to provide some such absorbent medium have been made, and of them the most practical and successful is, undoubtedly, that by G. E. D. Ralls, the managing director of the Birmingham and Midland Counties' Transport Co., Ltd. His system of suspension was incorporated in a 5-ton gasoline chassis, the first model of which appeared during the war. The single torque and twin radius rods were spherically jointed at their front ends; the former to a single-ended lever on a hollow shaft, free to revolve, thus removing all longitudinal constraint from the torque rod; the latter to double-ended levers, keyed at about their centers to a common transverse shaft. The upper ends of these levers were forked and engaged horizontal plungers, which were held between a pair of substantial helical springs. In this manner provision was made for the horizontal elasticity. The device worked well.

After a little modification, the front springing of the chassis was constructed on similar lines to the rear, and the actual method of carrying this into effect may be gathered by reference to the accompanying drawing. In addition to making provision for absorption of horizontal shocks, which provision is very similar in principle to that adopted for the rear axle, there is also means for



A Partial Section of a New Spring Suspension as Applied to the Front End of a Motor Truck

accommodating that extra load which front springs are frequently called upon to bear when the axle almost bodily drops into the hollow of a "wave" in the road. It will be noticed that this supplementary cushioning is partly provided by the horizontal helical springs of the shock absorber and partly by a supplementary support for the spring itself. This support only becomes operative when the spring is considerably deflected, and its effect is equivalent to shortening the spring, thus rendering it temporarily stiffer, so that it is readily capable of withstanding the increased load. The short, additional half-leaf is provided to cushion the impact between the spring and a supplementary pin.—*Commercial Motor* (London).

POST-WAR USE OF ALLIES' INVENTIONS

THE Director of Air Service, War Department, has issued a statement calling attention to the fact that after the deposit of ratifications of the treaty of peace by Germany and three of the principal associated powers, American manufacturers of airplanes, engines and accessories must discontinue the use of all articles upon which patents are held by British manufacturers until a special arrangement is made through the Air Service with the United States Government by which the latter agrees to assume any liability for such use. This arrangement is in accordance with an agreement between Great Britain and the United States which provided that during the war the British Government would assume any liability in respect to the rights of the British manufacturers for the production of airplanes, engines or accessories by American manufacturers and that after the war such production should cease. This agreement applies to practically all of the Allied Powers, verbal understandings of a similar nature having been arrived at.

The 450-Hp. Napier Lion Engine

THE all-British Lion aeronautic engine has many points of interest. The most noticeable feature of the latest model is the new type of water-jacket. There is now a separate jacket to each cylinder instead of a multiple jacket for each block of four cylinders. Weight is saved, and the new method of making a water-tight joint between the cylinder and the jacket is preferable to the old. In the former models the lower joint was made by a rubber ring; in the latest type the jackets are welded to the cylinders.

The Lion engine, which develops 450 b.hp. at 2000 r.p.m., weighs only 1.86 lb. per b. hp., without water, fuel or oil. Its twelve cylinders are arranged in three sets in the "broad arrow" method. Each cylinder has two inlet and two exhaust valves with the seats screwed through the head of the cylinder into the head casting. The valves are operated by two overhead camshafts, and the cams act directly upon the tappet heads, the stems of which are screwed into the valve stems so that the clearance may be adjusted. A spring locking ring secures the tappet head when the adjustment has been made.

Starting Device

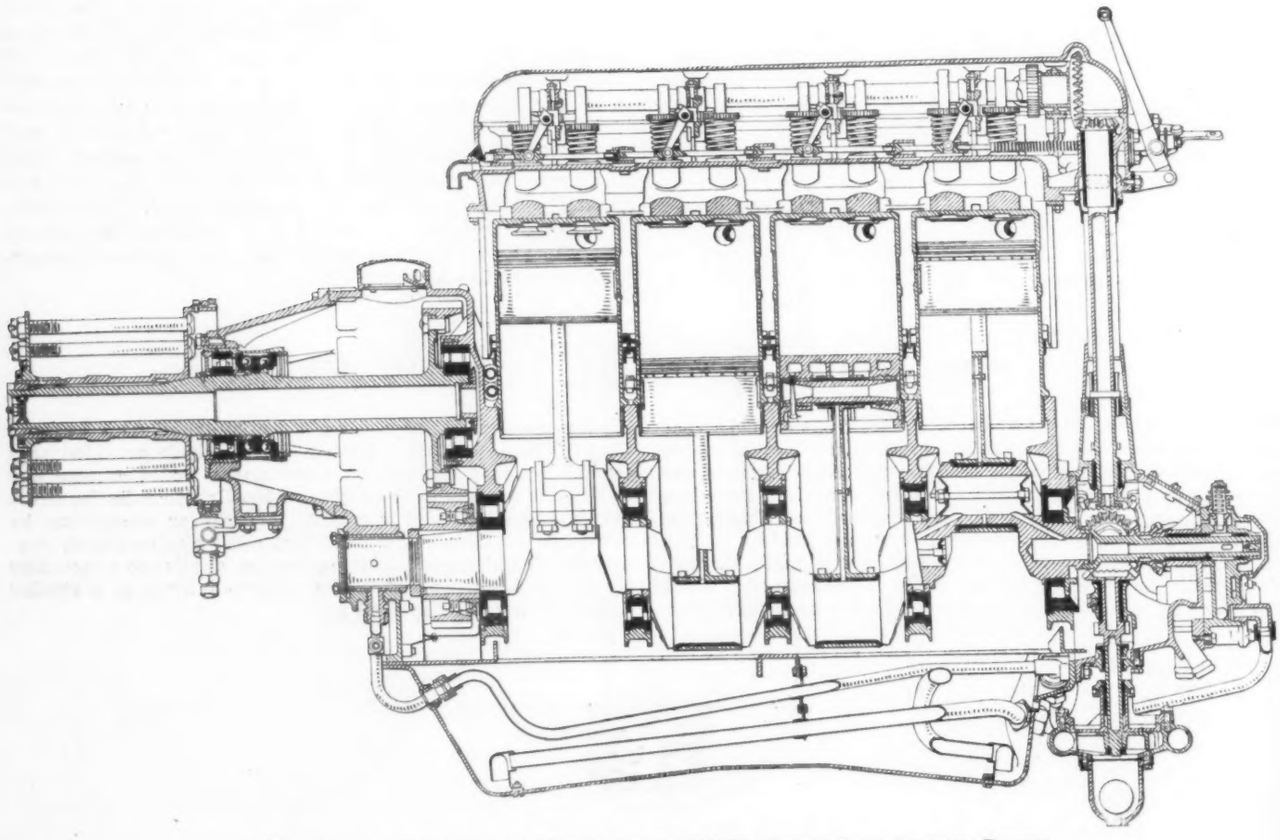
The engine is started by pumping an explosive mixture into the cylinders and firing it by a hand-starting magneto. Linked control levers enable the two forward valves of each cylinder to be opened by hand. The air-pump is mounted in the cockpit, and by a two-way cock it can be used first to pump pure air to the cylinders to expel any foul gases that there may be in the combustion chambers, and then the explosive mixture is ready for firing. The mixture is formed by pumping air through a vaporizer which is a form of spray carbureter.

The three rows of cylinders are supplied with mixture, when running, by two carbureters, a single and a duplex type. The gas passages are water-jacketed. So far as the throttles, diffusion jets and altitude control cocks are concerned the carbureters resemble the HC7 type, but modifications have been made to adapt them to the Lion engine.

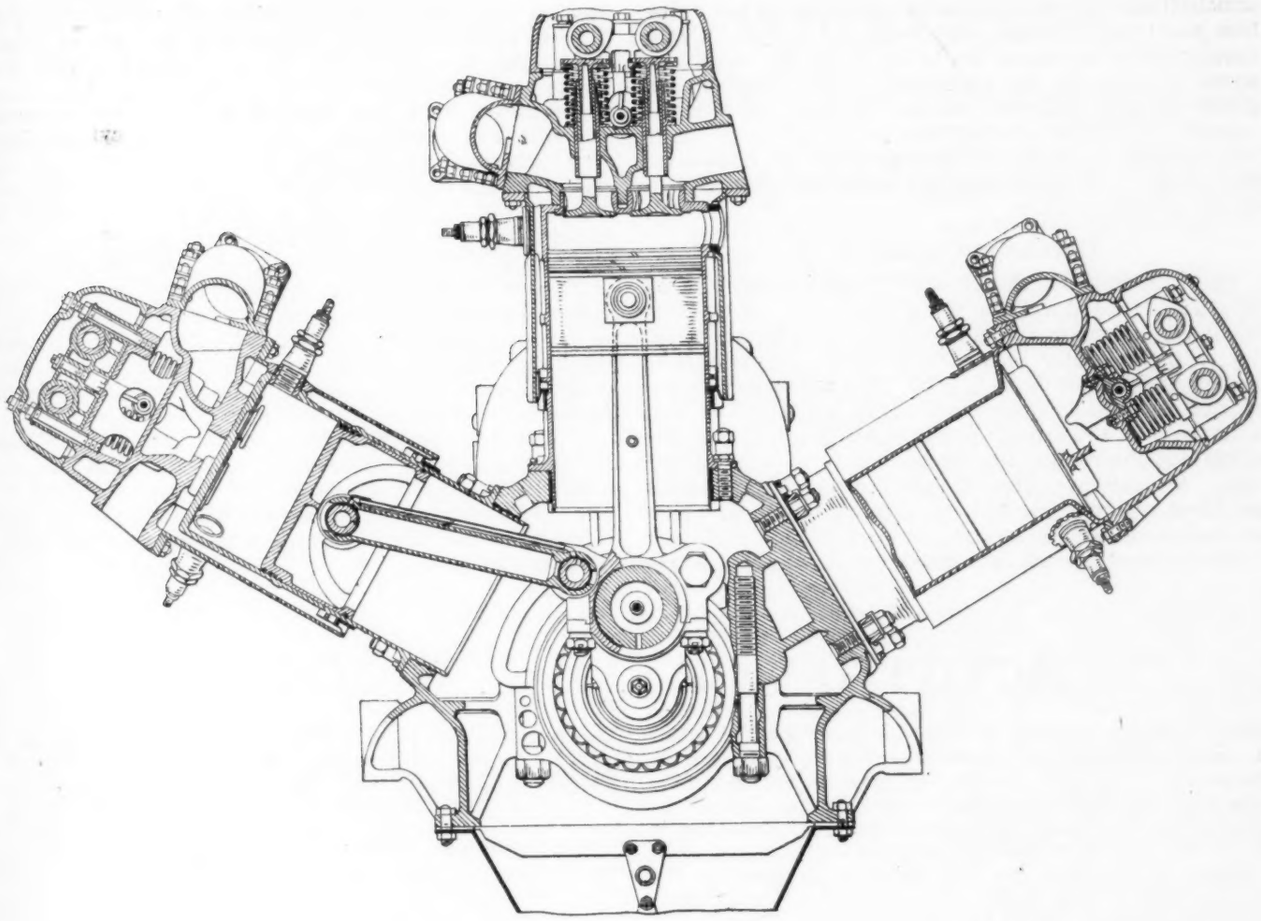
The altitude control system is that of reducing the supply of gasoline as the machine climbs. This is, of course, necessary, because as the air becomes rarefied the percentage of air to gasoline would become incorrect if the flow of fuel were not checked. There is a safety device which causes the control to shut automatically when the throttle is closed. This prevents the mixture being too weak when the pilot makes a long dive and flattens out.

Lubrication and Ignition

Oil-pumps of the spur-wheel type are fitted and the lubricant is fed under pressure to both ends of the crank-shaft and thence along the inside of the shaft to the crankpins and to the big-ends and piston pins. Oil is also supplied under pressure to one of the camshafts on



Longitudinal Elevation in Section of the 450-Hp. Napier Lion Aircraft Engine



SECTIONAL END ELEVATION

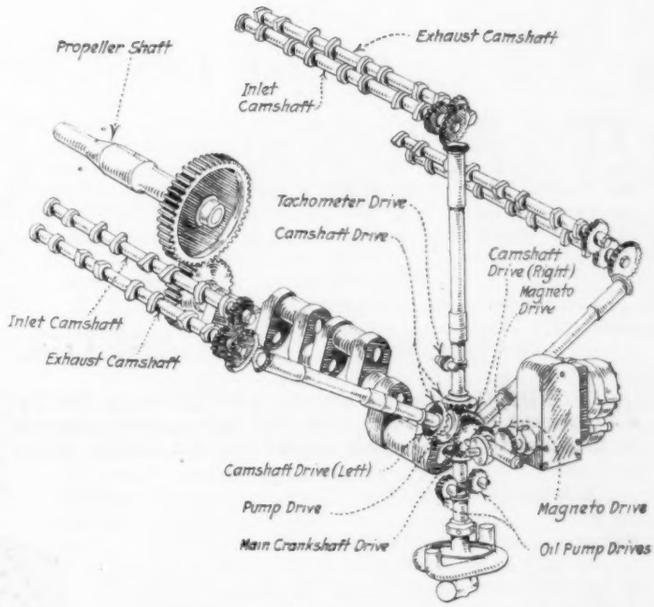
each set of cylinders and to the reduction gears. The cylinders are lubricated by oil splashed from the connecting-rod big-end bearings and the piston. Two scraper rings are fitted to each piston and the oil from the upper scraper ring is drained through holes cut in the piston.

Two twelve-cylinder magnetos are fitted. They are of the AV12 type manufactured by the British Thomson-Houston Co. Ltd. Both rotate in a counter-clockwise direction and one has a special distributor rotor for starting purposes. They are driven at one and a half times the speed of the crankshaft to give six sparks for each revolution of the engine, as this type of magneto gives four sparks to each revolution. Two plugs are, of course, fitted to each cylinder. Those recommended by the builder are the KLG type F10.

CRANKCASE

The crankcase of the Lion engine is a fine aluminum alloy casting. The upper halves of the housings for the crankshaft plain and roller bearings are contained in the two ends and four internal cross-webs. The lower halves of the housings for the roller bearings are steel caps carried in studs in the rear and cross webs.

The casing for the reduction gear is formed at the front end of the crankcase. The gearing is clearly shown in one of the accompanying illustrations. It will be seen that the arrangement is very compact. There are six camshafts, two for each set of cylinders, one operating the exhaust and one the inlet valves. Only one



ARRANGEMENT OF DISTRIBUTION GEARS

camshaft on each set of cylinders is driven by the reduction gear; the other camshaft is geared to this. Consequently, there are three shafts driven by the bevel gear wheel attached to the crankshaft. The diagram also shows that one shaft has two bevel wheels, one of which engages with the bevel wheel that drives the center shaft. The compact arrangement by which the six camshafts, water-pumps, oil-pumps and two magnetos are driven is clearly shown.

Details of Construction

The cylinders, which are steel forgings machined all over, are arranged in three sets of four each, one cylinder being vertical, with the other two making angles of 60 deg. with its center line. The bore of the cylinder is 5½ in. and the stroke is 5⅛ in. The water-jackets are of steel and the cylinder-head which is detachable contains the inlet and exhaust passages and together with the valves and their actuating mechanism is made of aluminum. An aluminum alloy is used for the pistons, which are fitted with two gas and two scraper rings. The pins are hollow, of large diameter and work in steel bushings.

The connecting-rods are machined from high-grade special steel. The main rod, which is coupled to the pistons of the vertical block of cylinders, has lugs at either side which are attached to the short auxiliary rods for the pistons of the right and left groups of cylinders. The big-ends are lined with white metal and together with the anchor pins and other parts work in large bushings. The crankshaft is machined from a solid steel forging with the four throws in one plane. All the journal bearings of the crank-pins are of large diameter and are bored out. Five roller bearings and a large plain bearing at the forward end are provided for the shaft.

The water-pump is of the centrifugal type and is mounted at the rear of the engine. Its speed is half that of the crankshaft and the circulating water is delivered through a separate outlet to each of the cylinder blocks. A metallic packed gland and a grease cup with screw feed are provided for the pump.

The engine has an overall length to the center of the propeller of approximately 4 ft. 8 in. and an approximate overall width of 3½ ft. The height overall is about 3 ft. The fuel consumption is approximately 0.51 pt. per b. hp.-hr. at full load and the oil consumption is 0.02 pt.—*Aeronautical Engineering.*

ACTIVITIES OF S. A. E. SECTIONS

THE January meeting of the Cleveland Section which would ordinarily be held on the 16th has been omitted. The next meeting of the Section will occur on Feb. 20, in the library of the Hotel Statler. A paper on the Commercial Possibilities of Aircraft will be presented by a representative of the Wright-Martin Aircraft Corporation.

Robert W. Carington has been appointed chairman of the Meetings and Papers Committee of the Mid-West Section, succeeding Mark A. Smith, who has gone to Indianapolis.

At the November meeting of the Detroit Section, which was held on the 28th, about 250 members and guests listened to two interesting addresses dealing with conditions in Europe. The first speaker was C. C. Hanch, who explained that as a result of the war the productive manhood of Europe had contracted the habit of idleness. He emphasized that Bolshevism was not new but was simply a new name for a very old condition of mind in man and existed in practically all the countries of the world. In his address H. E. Coffin pointed out that economic quantity production is the life of any industrial civilization and that America is no exception to this general rule. The monthly meeting of the Section, which would under ordinary conditions be held on Jan. 23, will be omitted on account of the Annual Meeting of the Society and the automobile shows at New York City and Chicago.

BRITISH DEVELOPMENT OF AVIATION

THE Air Service has announced that a committee composed of the members of the British Air Ministry and of the aviation industry has been sitting for two months under the chairmanship of the Under Secretary of State for Air to consider the question of the future development of aviation on lines of increased safety. A large number of witnesses has been called, including constructors and designers and representatives of the public who are interested in aviation. It has been decided, as stated in Parliament, to institute a competition open to the British Empire. Prizes, amounting in value to £64,000, will be awarded by the Government for the best plans submitted for the safeguarding of aircraft.

INCREASED RUBBER IMPORTS

ACCORDING to figures recently made public by the Department of Commerce there has been a great increase in the importation of crude rubber into the United States recently. In October, 1919, the imports aggregated 28,888 tons, or three times the amount which was brought in during the corresponding month of 1917.

PERSONAL NOTES OF THE MEMBERS

James A. Abeles has resigned as manager of the Beckley-Ralston Co., New York City, and has been elected vice-president of the recently organized Boyce-Veeder Corporation, Long Island City, N. Y., which will manufacture an automatic hand-operated fire extinguisher for motor cars, trucks, tractors, airplanes and other automotive vehicles.

Arthur Berndt, who was formerly an aeronautical mechanical engineer in the employ of the Bureau of Aircraft Production, has left the United States and is now located in London.

Harrison H. Boyce, vice-president and general manager, Moto-Meter Co., Inc., Long Island City, N. Y., has organized the Boyce-Veeder Corporation, also of that city. He has been elected president of the new organization and will divide his time between that and the Moto-Meter Co.

Robert P. Burrows, who was formerly in charge of the commercial section, engineering department, of the National Lamp Works of the General Electric Co., Cleveland, Ohio, has been appointed sales engineer of the recently organized Electric Sales & Engineering Co., also of that city. He will be in charge of all the commercial activities of the company.

James M. Carples is now located at Rochester, N. Y., where he is the representative of H. W. Noble & Co., Detroit, Mich. He was formerly a member of the organization staff of the Detroit Motorbus Syndicate.

John Cetrule, who has been serving in the motor transport division of the Reserve Officers' Training Corps at Camp Nyssa, Farmingdale, N. Y., has been discharged from the service of the Government and has accepted the position of assistant chief engineer with J. H. Wilhelm, Inc., consulting engineer, New York City.

A. R. Clas, president of the Toledo Steel Products Co., Toledo, Ohio, has been elected a director and vice-president of the recently incorporated Toledo Automotive Products Co., also of that city.

Charles S. Crawford has been appointed vice-president in charge of engineering with the Premier Motor Corporation, Indianapolis, Ind. He was formerly engineering director and assistant general manager.

J. W. DeCou, who has been factory manager of the Ross Gear & Tool Co., Lafayette, Ind., has been appointed vice-president and general manager of the recently organized Fairfield Mfg. Co., also of that city.

Gordon M. Evans has been discharged from the engineering division of the Ordnance Department with the rank of captain and has accepted a position in the Detroit office of the Aluminum Castings Co., Cleveland, Ohio.

Harry Fosdick has been appointed vice-president of the Monroe Motor Car Co., Buffalo, N. Y. He was formerly a special representative of the Nordyke & Marmon Co., Indianapolis, Ind.

Capt. Clarence M. Foss, who has been stationed at the Raritan Arsenal, Metuchen, N. J., has been promoted to major and appointed chief of the enlisted personnel branch in the office of the Chief of Ordnance.

R. G. Garretson has resigned as chief draftsman with the National Motor Car & Vehicle Corporation, Indianapolis, Ind., and has accepted a position as engineer with the Clark Truck-tractor Co., Buchanan, Mich.

G. H. Hedrick, who was formerly an inspector in the Bureau of Aircraft Production and stationed at Swissvale, Pa., has accepted the position of service engineer with the Samson Motor Car Co., Inc., Pittsburgh, Pa.

Capt. Harry S. Hegy, who has been stationed at the plant of the Locomobile Co. of America, Bridgeport, Conn., as officer in charge of inspection for the Ordnance Department, has been transferred to the tank, tractor and trailer division at Washington.

Earl V. Higbee has been appointed assistant chief engineer with the Locomobile Co. of America, Bridgeport, Conn.

E. L. Jaco has been discharged from the Quartermaster Corps with the rank of major and has accepted a position as district manager for the states of Indiana and Ohio with the Twin City Co., Minneapolis, Minn. His headquarters are at 47 Kentucky Avenue, Indianapolis, Ind.

Charles G. King has resigned as factory superintendent of the Le Roi Co., Milwaukee, Wis., and is now engaged in development work with the Miles Piston Ring Co., Chicago, Ill. He expects to sail for England in the near future.

V. C. Kloepper has accepted a position as chief engineer with the Astra Motors Corporation, St. Louis, Mo. He was formerly chief engineer of the automotive department of the National Tool & Mfg. Co., also of that city.

M. A. Mikesh, who has been serving as an inspector for the Bureau of Steam Engineering, Navy Department, at the plant of the Allis-Chalmers Mfg. Co., West Allis, Wis., has been discharged from Government service and has accepted a position in the engineering department of the Newport Co., Milwaukee, Wis.

Frederick P. Nehrbas, formerly general factory manager of the Premier Motor Corporation, Indianapolis, Ind., has been appointed vice-president and general manager.

David E. Ross, consulting engineer of the Ross Gear & Tool Co., Lafayette, Ind., will act in the same capacity for the Fairfield Mfg. Co., also of that city, which has recently been organized to manufacture differential and bevel gears for automobiles.

Edward A. Ross, secretary of the Ross Gear & Tool Co., Lafayette, Ind., will also act as secretary of the recently organized Fairfield Mfg. Co., also of that city.

G. S. Salzman, factory manager and treasurer of the Grant Motor Car Corporation, Cleveland, Ohio, has been elected a director and secretary of the Toledo Automotive Products Co., Toledo, which was recently incorporated to manufacture high-grade screw machine and hardened and ground products for the automotive industry.

W. S. Sandeman, who was formerly a statistical road man for the Findeisen & Kropf Mfg. Co., Chicago, Ill., has been given charge of the territory surrounding New York City by its successor, the Beneke & Kropf Mfg. Co. His headquarters are at the Wagner Specialty Co., 1902 Broadway, New York City.

Edwin M. Smith has resigned as drafting engineer in the engineering department of the Holt Mfg. Co., Peoria, Ill., to accept the position of drafting-room manager with the Pittsburgh Model Engine Co., Pittsburgh, Pa.

Charles E. Thompson, president of the Steel Products Co., Cleveland, Ohio, has been elected a director of the recently incorporated Toledo Automotive Products Co., Toledo, Ohio.

W. E. Tregenza has resigned as master mechanic and efficiency engineer with the Canadian Aeroplanes, Ltd., Toronto, Ont., Canada, and is now located at Detroit, Mich.

A. M. Wolf, secretary of the Metropolitan Section and chief engineer of the I. Sekine Co., New York City, has recently received word that the Japanese Government has officially approved, as subject to the Government subsidies, the Sekine truck which he designed and built. The truck was designed to conform to the particular specifications formulated by the Japanese Government under its subsidy bill. Before receiving the Government approval two trucks which were shipped to Japan were subjected to a 1000-km. road test and others for hill-climbing ability on each gear, minimum turning radius and gasoline and oil consumption. The parts and trucks themselves were inspected before and after the tests as well as being looked over to ascertain that the weights, measurements, equipment, etc., conformed to the Government speci-

fications. Mr. Wolf was one of the organizers of the American Motors Corporation, and while with that organization designed the American Six.

Applicants *Qualified*

The following applicants have qualified for admission to the Society between Nov. 22 and Dec. 27, 1919. The various grades of membership are indicated by (M) Member; (A) Associate Member; (J) Junior; (Aff.) Affiliate; (Aff. Rep.) Affiliate Representative; (E. S.) Enrolled Student; (S. M.) Service Member; (F. M.) Foreign Member.

AINSWORTH, BERTRAM W. (M) truck sales engineer, Locomobile Co. of America, *Bridgeport, Conn.*

AYERS, MARQUIS H. (E. S.) student, University of Michigan, *Ann Arbor, Mich.*, (mail) 805 East Huron Street.

BAKER, GEORGE C. (M) body designer, James Cunningham, Son & Co., *Rochester, N. Y.*, (mail) 346 Woodbine Avenue.

BALDWIN, CURTIS C. (M) president, Savage Harvester Co., *Sparta, Mich.*, (mail) Box 1258, *Denver, Col.*

BATESOLE, DWIGHT EDWARD (M) mechanical engineer, Norma Co. of America, Anable Avenue, *Long Island City, N. Y.*

BATTERSON, D. C. (J) mechanical engineer, Williamson Hydraulic Clutch Co., *Mount Vernon, Ohio*, (mail) Y. M. C. A.

BERG, ROY E. (J) editorial department, *Motor Age, Chicago, Ill.*, (mail) 11249 Longwood Drive.

BIGGAR, P. E. (J) student, McGill University, *Montreal, Canada*, (mail) 70 McGill College Avenue.

BIRCHLER, HARRY I. (J) mechanical draftsman, Fifth Avenue Coach Co., *New York City*, (mail) 26 West 125th Street.

BISP, WILLIAM EDWARD (J) draftsman, Militor Corporation, *Jersey City, N. J.*, (mail) 80 Zabriskie Street.

BOHN, CHARLES B. (A) president, Charles B. Bohn Foundry Co., 738 Hard Avenue, *Detroit, Mich.*

BOOR, ARTHUR (M) engineer, International Fabricating Corporation, *Wilkes-Barre, Pa.*

BRAMWELL, JOSEPH W. (M) sales engineer, American Bronze Corporation, *Berwyn, Pa.*

BROSSEAU, CONRAD L. (J) sales promotion engineer in China, International Motor Co., New York City, (mail) care of Andersen Meyer & Co., *Shanghai, China.*

BROWN, FRED (A) president, Brown & Kragness, *New York City*, (mail) 2405 Broadway.

BURR, HARRY BALDWIN (A) sales engineer, Klaxon Co., Newark, N. J., (mail) 3066 West Grand Boulevard, *Detroit, Mich.*

BUSH, PHILIP M. (A) assistant general manager and treasurer, Bush Mfg. Co., *Hartford, Conn.*, (mail) 198 Kenyon Street.

CAVANAGH, EVERETT (M) sales engineer, Bimel Spoke & Auto Wheel Co., *Portland, Ind.*

CEDERLEAF, FRED W. (M) chief engineer, Sparks-Withington Co., *Jackson, Mich.*, (mail) 305 South Thompson Avenue.

CHEEL, HAROLD WILLIAM (J) Bonner-Charter Motor Co., *Chicago, Ill.*, (mail) 5066 Broadway.

CONHEIM, RICHARD J. (A) president, Metals & Chemical Corporation, 3312 Woolworth Building, *New York City.*

COX, CAPT. ABRAHAM BEEKMAN (M) testing and experimental work, motor section, Ordnance Reserve Corps, 55 Liberty Street, *New York City.*

CUTTER, JOHN D. (M) metallurgist, Crucible Steel Co. of America, Pittsburgh, Pa., (mail) 473 Lafayette Boulevard, *Detroit, Mich.*

DAHL, BRUNO (M) engineer, automotive department, Standard Steel Car Co., Pittsburgh, Pa., (mail) 572 Coal Street, *Wilkinsburg, Pa.*

DALTON, JOHN (E. S.) student, Cornell University, (mail) 777 Stewart Avenue, *Ithaca, N. Y.*

DAVIES, J. E. (A) president, Alberta Foundry & Machine Co., Ltd., Medicine Hat, *Alberta, Canada.*

DE FLOREZ, LUIS (M) Cochrane, Harper & Co., 60 State Street, *Boston, Mass.*

DICKEY, ERNEST (M) assistant chief engineer Domestic Engineering Co., *Dayton, Ohio.*

DICKOVER, I. CLAYTON (A) production engineer, Maccar Truck Co., *Scranton, Pa.*

DOERR, ARCHIBALD LLOYD (A) Pacific coast district manager, Clydesdale Motor Truck Co., Clyde, Ohio, (mail) Hotel Whitcomb, *San Francisco, Cal.*

EDWARDS, EATON G. (A) G & O Mfg. Co., *New Haven, Conn.*, (mail) 217 Nicoll Street.

ELLIOTT, EDWARD (M) assistant chief engineer, Osgood Bradley Car Co., *Worcester, Mass.*, (mail) Worcester Automobile Club, 44 Front Street.

FABRIQUE NATIONALE D'ARMES DE GUERRE (Aff.) *Herstal-lez-Liége, Belgium.* Representative: Alexandre Galopin, general manager.

FIRTH-STERLING STEEL CO. (Aff.) *McKeesport, Pa.* Representative: Roy H. Davis, general manager.

FLANNERY, WALTER R. (A) salesman, Vanadium Corporation of America, Vanadium Building, *Pittsburgh, Pa.*

FLEMING, DIO C. (M) assistant inspector of ordnance materials and motor vehicles, Holt Mfg. Co., *Peoria, Ill.*

GARDNER, FRED W. (A) vice-president in charge of production, Gardner Motor Co., *St. Louis, Mo.*

GIBBONS, H. RALSTON (M) experimental engineer, Hyatt Roller Bearing division, General Motors Corporation, *Newark, N. J.*

GILLES, PIERRE P. (M) chief engineer, McFell Signal Co., 2857 South Halstead Street, *Chicago, Ill.*

GOLDMAN, FIRST LIEUT. JAY M. (A) general staff, Quartermaster Corps, *Washington*, (mail) 1743 Munitions Building.

GORMAN, THOMAS J. (J) engineer and purchasing agent, Meteor Motors, Inc., *Philadelphia, Pa.*, (mail) 8538 Frankford Avenue.

GROSS, MORTON G. (E. S.) student, Armour Institute of Technology, *Chicago, Ill.*, (mail) 5312 Calumet Avenue.

HAGEMAN, DONALD (J) Curtis Bay Copper & Iron Works, *South Baltimore, Md.*

HANCHETTE, D. N. (M) assistant engineer, Elwell-Parker Electric Co., *Cleveland, Ohio*, (mail) 10902 Hull Avenue.

HAREYAMA, NAOKICHI (E. S.) student, college of engineering, University of Michigan, *Ann Arbor, Mich.*, (mail) 301 North State Street.

HASKINS, HOWARD B. (J) experimental engineer, Ford Motor Co., *Detroit, Mich.*, (mail) 120 Pallister Avenue.

HIBI, KATSUHARU (F. M.) engineer, Mitsui Mining Co., Surugacho, Nihoubashiku, *Tokyo, Japan.*

HILL, THOMAS MARTIN (J) designing draftsman, Electric Wheel Co., *Quincy, Ill.*, (mail) 631 Jersey Street.

HOLLISTER, WILLIAM H. (A) sales engineer, Imperial Brass Mfg. Co., Chicago, Ill., (mail) 143 South Euclid Avenue, *Oak Park, Ill.*

HOLMAN, EARL L. (E. S.) student, University of California, *Berkeley, Cal.*, (mail) 2717 Derby Street.

HOPKINS, A. R. (J) chief draftsman, Lang Body Co., *Cleveland, Ohio*, (mail) 495 East 123rd Street.

HORNER, FRANK G. (M) automotive engineer, Alaska Autosleigh Co., 907 White Building, *Seattle, Wash.*

HOTZ, ALF. M. (A) president and manager, Hotz Foundry & Mfg. Co., *Fremont, Ohio.*

HUBBARD, DENNIS L. (M) engineer, truck division, American Auto Trimming Co., *Detroit, Mich.*, (mail) 218 St. Clair Avenue.

JASCHKA, JOHN H. (M) sales engineer, National Malleable Castings Co., *Cleveland, Ohio*, (mail) 7706 Platt Avenue.

JENKINS, A. F. (M) general superintendent, Dort Motor Car Co., *Flint, Mich.*, (mail) 1214 Avenue C.

JESCH, PAUL JOHN (A) designer, Brewster & Co., Long Island City, N. Y., (mail) 1032 Washington St., *Hoboken, N. J.*

JONES, ARTHUR (A) president and treasurer, Arthur Jones Electric Co., 2837 South State Street, *Chicago, Ill.*

JONES, HUGH IVOR (A) assistant metallurgist, Willys Morrow Co., *Elmira, N. Y.*

KEENAN, WILLIAM J. (A) truck engine draftsman, Bethlehem Motors Corporation, *Pottstown, Pa.*, (mail) Box 291.

KELLER, GROVER E. (A) tool designer, Holt Mfg. Co., Stockton, Cal., (mail) care of Y. M. C. A., *Portland, Ore.*

KELLOGG, RALPH S. (J) layout draftsman, Dort Motor Car Co., *Flint, Mich.*

KING, LLEWELLYN A. (M) chief inspector, National Motor Car & Vehicle Co., 2437 Bellefontaine Street, *Indianapolis, Ind.*

KNAPP, ARTHUR (A) president, Arthur Knapp Engineering Corporation, 19 West Forty-fourth Street, *New York City.*

KNOCH, F. E. (M) general superintendent, United Oil Co., *Florence, Colo.*

KNOPP, W. R. (A) sales department engineer, Dayton Engineering Laboratories Co., *Dayton, Ohio.*

KNUDSEN, H. L. (M) chief engineer, Iron Mountain Co., 927 East Ninety-fifth Street, *Chicago, Ill.*

LANNON, JOHN D. (A) superintendent, Savage Arms Corporation, *Sharon, Pa.*

LATTNER, PAUL M. (A) proprietor, Electric Service Station, *Cedar Rapids, Iowa*, (mail) 616 Second Avenue.

LEGG, WILLIAM F. (M) mechanical engineer, 660 West 180th Street, *New York City.*

LEWIS, ROBERT P. (J) aeronautical draftsman, Naval Aircraft Factory, League Island Navy Yard, *Philadelphia, Pa.*, (mail) 1340 Spring Garden Street.

LOCKWOOD, E. H. (M) assistant professor of mechanical engineering, Sheffield Scientific School, Yale University, *New Haven, Conn.*, (mail) 51 Sheldon Terrace.

MCWILLIAMS, JAMES BRUCE (M) general manager, Hero Mfg. Co., Twenty-third and West Moreland Streets, *Philadelphia, Pa.*

MACK, ERNEST D. (A) mechanical and electrical engineer, Mack Brothers, Inc., *Reno, Nev.*, (mail) Box 635.

MACLAREN, ALFRED M. (A) sales engineer, S K F Industries, Inc., 115 New Montgomery Street, *San Francisco, Cal.*

MANUFACTURERS AIRCRAFT ASSOCIATION, INC., (Aff.) 501 Fifth Avenue, *New York City.* Representatives: Luther K. Bell, information department; Samuel S. Bradley, general manager.

MEANS, RALPH P. (M) general manager, Carde Stamping & Tool Co., *Saginaw, Mich.*, (mail) 513 Cedar Street.

MERCHANT, ROSCOE C. (M) sales engineer, Covert Gear Co., Inc., 967½ Woodward Avenue, *Detroit, Mich.*

MORRIS, HARRY T. (M) metallurgical engineer, Bethlehem Steel Co., *Bethlehem, Pa.*

NOBLE, W. W. (A) secretary and assistant general sales agent, Carbon Steel Co., *Pittsburgh, Pa.*, (mail) Box 1591.

OGREN, CARL FRANCIS (J) plant engineer, American Bronze Corporation, New York City, (mail) 74 Kenilworth Place, *Brooklyn, N. Y.*

OSTROM, CLAUDE C. (A) sales manager, Washington Steel & Ordnance Co., *Washington.*

PATCH, HARRY M. (A) engineer, Patch Differential Co., *Seattle, Wash.*, (mail) 4323 Tenth Avenue, Northeast.

PATTULO, MILTON D. (J) service manager and tractor engineer, Monarch Tractor Co., *Watertown, Wis.*, (mail) 308 South Sixth Street.

PETRELLI, JOSEPH V., SR. (A) proprietor, Navy Gear Mfg. Co., *New Haven, Conn.*

PIETSCH, LAWRENCE WILLIAM (A) lubricating engineer, Standard Oil Co., *Chicago, Ill.*, (mail) 665 Diversey Parkway.

POHLMANN, EDWARD CHARLES (J) assistant editor, *American Garage and Auto Dealer, Chicago, Ill.*, (mail) 116 South Michigan Avenue.

POUNSETT, FRANK H. (M) mechanical transport inspector Canadian Army, Ottawa, Ont., (mail) 21 Tennis Crescent, *Toronto, Ont., Canada.*

PRUDEN, R. M. (J) foreman, Advance Rumely Co., *La Porte, Ind.*, (mail) 510 First Street.

PUSEY, WESLEY B. (J) engineering department, Hart-Parr Co., *Charles City, Iowa.*

RANDALL, J. MALCOLM (J) experimental engineer, Service Motor Truck Co., *Wabash, Ind.*, (mail) Box 44.

RAUHAUSER, GEORGE C. (J) designer, Packard Motor Car Co., *Detroit, Mich.*, (mail) 308 Putnam Avenue.

REPLOGLE, JOHN R. (M) chief engineer, Frigidaire Corporation, *Detroit, Mich.*, (mail) 1370½ Helen Avenue.

REYNOLDS, CARL R. (M) chief draftsman, engineering department, Wheeler-Schebler Carburetor Co., Inc., Shelby, Sanders and Bath Avenues, *Indianapolis, Ind.*

RICHARDSON, FRED J. (M) assistant engineer, National Motor Car & Vehicle Corporation, *Indianapolis, Ind.*

RICHARDSON, G. F. (A) foreman, Marburg Brothers, Inc., New York City, (mail) 2289 Pitkin Avenue, *Brooklyn, N. Y.*

RITCHIE, LIEUT.-COL. J. M. (S. M.) chief of operations division, Motor Transport Corps, *Washington*, (mail) 1824 Sixteenth Street, Northwest.

ROBERTS, EDWARD K. (M) sales manager, Bush Mfg. Co., *Hartford, Conn.*, (mail) 179 Kenyon Street.

RODDEWIG, GIL F. (J) draftsman, Velie Motors Corporation, *Moline, Ill.*

ROGERS, CLARENCE E. (M) chief engineer, Huffman Brothers Motor Co., *Elkhart, Ind.*, (mail) 1020 West Franklin Street.

ROOF, ROBERT M. (M) chief engineer and vice-president, Laurel Motors Corporation, *Anderson, Ind.*

ROSENBLOOM, ABRAHAM E. (J) layout draftsman, Buick Motor Co., *Flint, Mich.*, (mail) 410 East Witherbee Street.

ROTHWEILER, H. N. (A) proprietor, Rothweiler & Co., *Seattle, Wash.*, (mail) 2962 First Avenue, South.

ROWAN, FRANK J. (A) 1423 Superior Street, *Racine, Wis.*

SANDERS, R. H. (J) draftsman, Duplex Engine Governor Co., *Brooklyn, N. Y.*, (mail) 97 Third Place.

SCHULT, PAUL F. (J) draftsman, Packard Motor Car Co., *Detroit, Mich.*, (mail) 1190 Crane Avenue.

SCHWATT, ERWIN L. (J) general manager, Auto-Marine Supply Co., Atlantic City, N. J., (mail) 1226 South Fifty-eighth Street, *Philadelphia, Pa.*

SERRE, CHARLES (F. M.) chief engineer and technical director, Automobiles Renault, Billancourt, (Seine) France, (mail) 55 Rue Molitor, *Paris, France.*

SMITH, H. R. (M) designer, Domestic Engineering Co., *Dayton, Ohio*, (mail) 243½ West Herman Avenue.

SPURLING, OLIVER C. (A) assistant general superintendent, Western Electric Co., Inc., Chicago, Ill., (mail) 224 South Ridgeland Avenue, *Oak Park, Ill.*

STEWART, GEORGE E. (J) draftsman, Holt Mfg. Co., *Stockton, Cal.*, (mail) 627 East Sonora Street.

STOLL, HERMAN (M) chief draftsman, Willys-Overland Co., *Toledo, Ohio*, (mail) Engineering Department, Boulevard.

STRIEDER, EDWARD H. (A) Hughes White Truck Sales Co., Dayton, Ohio, (mail) 217 Bosley Street, *Cincinnati, Ohio.*

TERRY, JOHN B. (M) chemist, Standard Oil Co. of California, *Richmond, Cal.*

THOMPSON, C. N. (M) engineer, Chandler Motor Car Co., *Cleveland, Ohio.*

THOMPSON, RUSSELL GRIFFITH (M) engineer, automotive equipment section, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa., (mail) 483 Campbell Street, *Wilkinsburg, Pa.*

TORGERSON, ALFRED C. (A) engineering manager, Torgerson Brothers, Billings, Mont.; partner, Main Street Garage, 7 Main Street, *Anaconda, Mont.*, (mail) Box 906.

VAN DERVOORT, F. M. (M) chief truck and tool designer, Mitchell Motors Co., *Racine, Wis.*, (mail) 221 Eleventh Street.

WAERNER T. A. (M) engineer, Tide Water Oil Co., 11 Broadway, *New York City.*

WALSH, EMMET I. (M) engineering department, motor truck division, Quartermaster General's Office, Washington, (mail) 1337 East Eighty-fourth Street, *Cleveland, Ohio.*

WALTER, CHARLES TAYLOR (E. S.) student, Armour Institute of Technology, *Chicago, Ill.*, (mail) 6404 Kenwood Avenue.

WEIHER, GEORGE F. (A) service engineer, Automotive Mfg. Co., *Dayton, Ohio*, (mail) 594 West Fifth Street.

WILLIAMS, MAJOR-GEN. C. C. (S. M.) chief of ordnance, War Department, *Washington.*

WILLIAMS, FRED D. (A) general manager, L. H. Gilmer Co., Tacony, *Philadelphia, Pa.*

WILSON, CYRIL (J) layout draftsman, National Motor Car & Vehicle Corporation, *Indianapolis, Ind.*

WINCHELL, HAROLD B. (J) engineer, William & Harvey Rowland, Inc., Frankford, *Philadelphia, Pa.*

WOLFF, JOHN F., JR. (J) mechanical engineer, Schwarz Wheel Co., Frankford, *Philadelphia, Pa.*

WOOD, CLARENCE P. (M) vice-president and engineer, Langwood Mfg. Co., 821 Bulletin Building, *Philadelphia, Pa.*

WYNNE, RICHARD J. (J) chief draughtsman, gas engine department, Sears, Roebuck & Co., *Chicago, Ill.*, (mail) 4018 North Ashland Avenue.

YENAWINE, W. D. (A) inspection foreman, Oakland Service Station, *Long Island City, N. Y.*, (mail) 167 First Avenue.

YOUNG, CAPT. G. R. (S. M.) chief of engineering branch, Motor Transport Corps, Seventh and B Streets, *Washington.*

Applicants *for* Membership

The applications for membership received between Nov. 29 and Dec. 29, 1919, are given below. The members of the Society are urged to send any pertinent information with regard to those listed which the Council should have for consideration prior to their election. It is requested that such communications from members be sent promptly.

ABRAHAMS, ARTHUR I., commercial engineer, Hale & Kilburn Corporation, 1800 West Lehigh Avenue, *Philadelphia, Pa.*

BARBER, LOUIS, designer and engineer, National Screw and Tack Co., East Seventy-fifth Street and Stanton Avenue, *Cleveland, Ohio.*

BARLING, WALTER HENRY, aeronautical engineer, airplane engineering department, Bureau of Aircraft Production, McCook Field, *Dayton, Ohio.*

BARTON, CLARENCE H., tractor and engine designer, Weidely Motors Co., *Indianapolis, Ind.*

BENNETT, HUBERT D., assistant chief clerk, Willys Overland Co., Inc., *Toledo, Ohio.*

BERRY, O. C., associate professor of gas and automotive engineering, Purdue University, *Lafayette, Ind.*

BETZ, IRVING K., designer and president, Betz Motor Truck Co., *Hammond, Ind.*

BIGELOW, W. C., sales manager, Yale & Towne Mfg. Co., *New York City.*

BRAND, MAURICE S., designing draftsman, American Sleeve Valve Motor Co., *New York City.*

BROWN, ARTHUR T., designing engineer, Dodge Engineering Co., 20 Alger Street, *South Boston, Mass.*

BRYAN, WILLIAM JAMES, sales manager, Budd Wheel Corporation, 1252 Book Building, *Detroit, Mich.*

BUSH, H. F., president and general manager, Auto Equipment & Service Co., Inc., *Philadelphia, Pa.*

BUTTERFIELD, CLAYTON W., sales manager, Dyneto Electric Corporation, *Syracuse, N. Y.*

CAMPBELL, ROBERT S., Pittsburgh Model Engine Co., *Pittsburgh, Pa.*

CHAPMAN, J. L., designer, Midwest Engine Co., *Indianapolis, Ind.*

CHAYNE, CHARLES A., instructor in mechanical engineering, Massachusetts Institute of Technology, *Cambridge, Mass.*

CHORLTON, HERBERT, experimental engineer, Brewster Co., *Long Island City, N. Y.*

CLARK, CHARLES S., sales manager, H. J. Koehler Motors Corporation, *Newark, N. J.*

CLARK, ELMER A., manager, Detroit branch, Rex Machine Co., 3201 Shields Avenue, *Chicago, Ill.*

COLEMAN, THOMAS E., vice-president, Madison-Kipp Corporation, *Madison, Wis.*

CONWAY, ARTHUR W., service engineer, Splitdorf Electric Co., 98 Warren Street, *Newark, N. J.*

CORSE, WILLIAM M., general manager, Monel Metal Products Corporation, *Bayonne, N. J.*

DANIELS, EUGENE T., general manager and secretary-treasurer, Master Primer Co., 34 East Larned Street, *Detroit, Mich.*

DE LONG, J. E., assistant engineer, Indiana Truck Corporation, *Marion, Ind.*

DEVOR, DONALD SMITH, works manager, Willys Corporation, *Elizabeth, N. J.*

DIEDERICH, JOHN W., experimental engineer, Dodge Brothers, *Detroit, Mich.*

DONNER, WILLIAM H., aeronautical engineer, Naval Aircraft Factory, League Island Navy Yard, *Philadelphia, Pa.*

DRUAR, F. J., chief engineer, Standard Motor Truck Co., *Detroit, Mich.*

EVANS, LLOYD L., patent engineer, Hydraulic Pressed Steel Co., *Cleveland, Ohio.*

FISHER, R. B., assistant to president, Buda Co., *Harvey, Ill.*

FORD, F. LESLIE, aeronautical engineer, Massachusetts Institute of Technology, *Cambridge, Mass.*

FOX, JOHN FUTHEY, draftsman, New York Navy Yard, *Brooklyn, N. Y.*

FURUSAWA, TAKESHI, professor, 12 Haramachi, Koishikawaku, *Tokyo, Japan.*

GAGE, MAJOR JOHN N., maintenance officer, Motor Transport General Depot, Municipal Pier, *Chicago, Ill.*

GELLATLY, WILLIAM R., production department, Pittsburgh Model Engine Co., *Pittsburgh, Pa.*

GILBERT, ALBERT H., chief engineer, Rock Island Plow Co., *Rock Island, Ill.*

GOREY, JOSEPH C., president, Joseph C. Gorey & Co., *New York City.*

GRAHAM, JAMES, lubrication engineer, Universal Lubricating Co., *Cleveland, Ohio.*

GRAHAM, JOHN, president, Paragon Tool Co., *Seattle, Wash.*

GULBRANDSEN, KARL, tester, Chevrolet Motor Co., *Flint, Mich.*

HANCH, C. C., general manager, Maxwell Motor Co., Inc., *Detroit, Mich.*

HAYNES, ROBERT B., motor design checker, Allison Experimental Co., *Indianapolis, Ind.*

HENSHAW, TRESCOTT A., truck designer, Stewart Motor Corporation, *Buffalo, N. Y.*

HERMAN, ISER, aeronautical draftsman, Air Service, Massachusetts Institute of Technology, *Cambridge, Mass.*

HIPSLEY, WILLIAM BURTON, Hipsley-Waddell, Ltd., *Sydney, New South Wales.*

HISE, FRED HENRY, designing engineer, Glenn L. Martin Co., *Cleveland, Ohio.*

HUCK, LOUIS C., engineer, 755 Waveland Avenue, *Chicago, Ill.*

HUGHES, H. F., sales manager, E. W. Bliss Co., *Brooklyn, N. Y.*

JOHNSTON, THOMAS HENRY, mechanical superintendent, Beach Motors, Ltd., *Ottawa, Ont., Canada.*

JORDAN, WILLIAM A., vice-president, United Motors Corporation, Inc., *Detroit, Mich.*

JOSSELYN, H. E., engineer salesman, Modine Mfg. Co., *Racine, Wis.*

KEITH, HERBERT A., general manager, Bowen Products Corporation, *Cleveland, Ohio.*

KELLEY, EDWARD WILLIS, designing draftsman, Electric Wheel Co., Walton Heights, *Quincy, Ill.*

KENT, P. J., electrical engineer, Studebaker Corporation, *Detroit, Mich.*

KENWORTH, ROBERT J., automobile spring-suspension, salesman, Standard Parts Co., *New York City.*

LEWIS, FRANK M., assistant professor, Webb Academy, Fordham Heights, *New York City.*

LOHMAN, RALPH W., chief engineer, Montana Farming Corporation, *Hardin, Mont.*

MACKENZIE, ROY J., president, Buffalo Pressed Steel Co., 778 Kensington Avenue, *Buffalo, N. Y.*

MCGRATH, RAYMOND D., assistant sales manager, Federal Pressed Steel Co., *Milwaukee, Wis.*

MCLACHLAN, JOHN, New York Telephone Co., 15 Dey Street, *New York City.*

MALONE, ALLEN L., secretary, S. K. F. Industries, Inc., 165 Broadway, *New York City.*

MATHEWS, VERNER P., sales engineer, Standard Parts Co., Perfection Spring plant, *Cleveland, Ohio.*

MEALEY, THOMAS A., salesman, Standard Parts Co., *New York City.*

MILLER, ROY G., physicist, National Advisory Committee for Aeronautics, Langley Field, *Hampton, Va.*

MILLER, THEODORE C., branch manager, American Bosch Magneto Corporation, *New York City.*

MONTGOMERY, ROBERT A., assistant to engineer, engineering branch, Motor Transport Corps, Seventh and B Streets, *Washington.*

MORGAN, CLINTON E., assistant general manager, Brooklyn City Railroad Co., *Brooklyn, N. Y.*

MORGAN, D., engineer, Lincoln Motors Co., *Detroit, Mich.*

MURRAY, HARRY E., assistant engineer, Bessemer Motor Truck Co., *Grove City, Pa.*

NEIN, CHARLES L., designer, International Motor Co., West End Avenue and Sixty-fourth Street, *New York City.*

NORTON, S. V., special representative of sales department, B. F. Goodrich Rubber Co., *Akron, Ohio.*

OSMUN, MAJOR R. A., Motor Transport Corps, *Washington.*

OTTINGER, LEON, patentee, 31 Nassau Street, *New York City.*

OWERSTROM, ROBERT A., draftsman, Amalgamated Machinery Corporation, *Chicago, Ill.*

PATRICK, I., assistant chief engineer, E. W. Bliss Co., 17 Adams Street, *Brooklyn, N. Y.*

PENDILL, PIERRE B., chief engineer, Hollis Tractor Co., 1709 Keenan Building, *Pittsburgh, Pa.*

PLEXICO, ROBERT SPRATT, assistant engineer and draftsman, Anderson Motor Co., *Rock Hill, S. C.*

POGUE, JOSEPH E., industrial economist and engineer, Sinclair Refining Co., *Chicago, Ill.*

POPE, COL. FRANCIS H., office, Chief of Motor Transport Corps, Seventh and B Streets, *Washington.*

POTTER, MELVILLE R., service manager, Genesee Motor Car Co., *Syracuse, N. Y.*

RICHARDSON, CARL VALLEAU, sales engineer, Hyatt Roller Bearing Co., *Chicago, Ill.*

ROBERTS, S. B., first assistant mechanical engineer, Bartram Bros., Inc., 17 Battery Place, *New York City.*

ROBERTS, S. M., vice-president, C. A. Roberts Co., *Chicago, Ill.*

ROZIAN, H. W., body designer, Federal Motor Truck Co., *Detroit, Mich*

SALTZMAN, HERBERT S., truck and tractor designer, Holt Mfg. Co., *Peoria, Ill.*

SCHELL, ARTHUR I., engineering department, Bethlehem Motors Corporation, *Pottstown, Pa.*

SEGNER, CHARLES B., vice-president and general manager, Domestic Engine & Pump Co., *Shippensburg, Pa.*

SEXTON, GEORGE L., mechanical engineer, Tractor Agricultural Sexton, *Detroit, Mich.*

SHATTUCK, C. P., Eastern technical representative, Chilton Co., *Philadelphia, Pa.*

SINGER, MAURICE A., automotive engineering, International Motors Co., 252 West Sixty-fourth Street, *New York City.*

SPRINK, ISAAC WILLIAM, tool supervisor, Warner Gear Co., *Muncie, Ind.*

SPURLING, O. C., assistant general superintendent, Western Electric Co., Inc., Hawthorne Station, *Chicago, Ill.*

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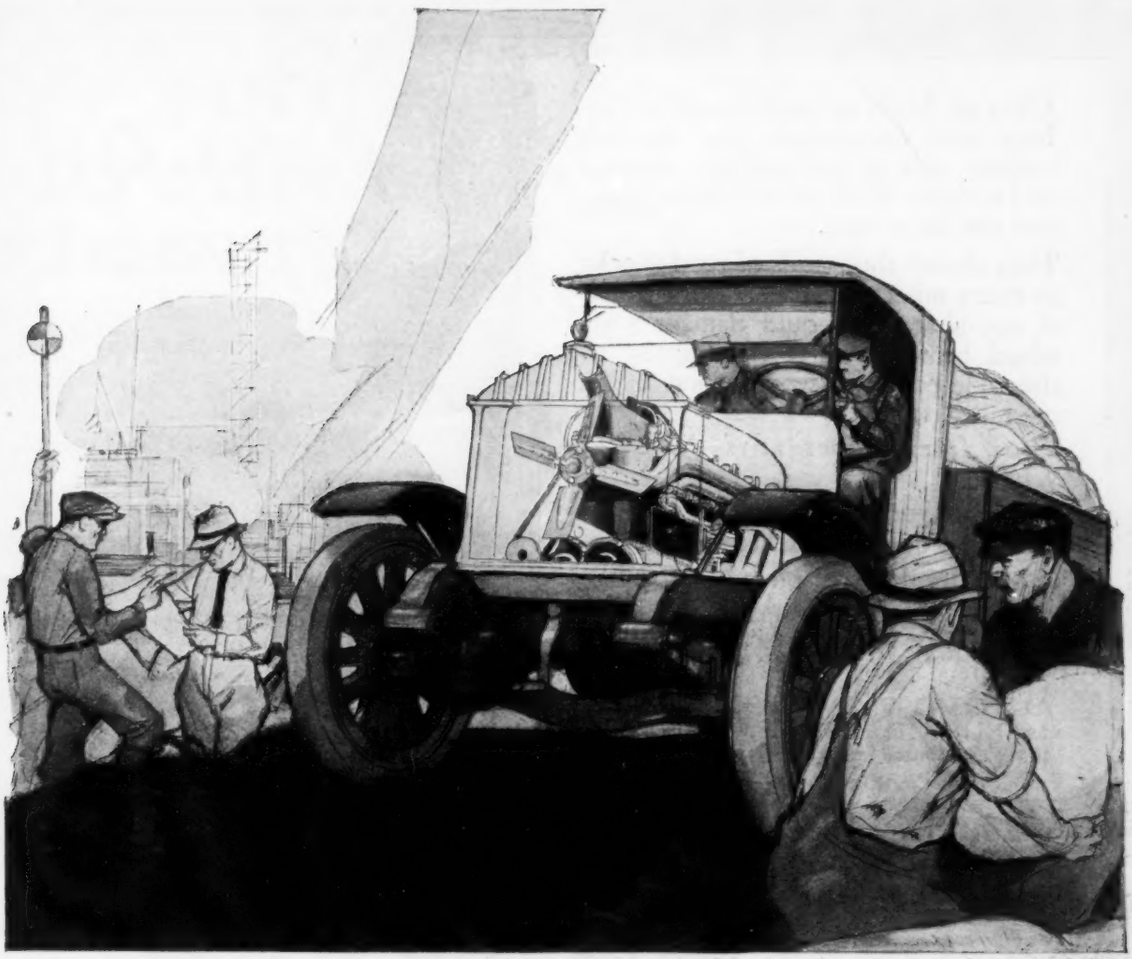

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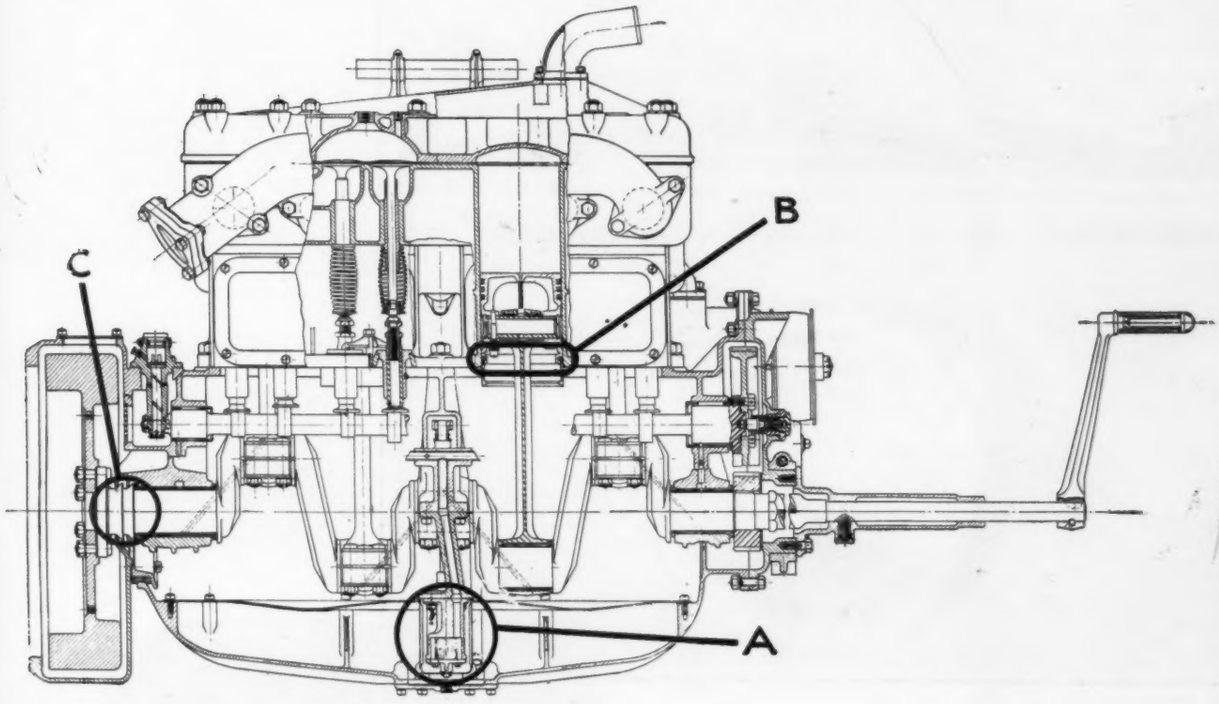
New York—8th Coast Artillery Armory, Main floor—Space 14-15-16.
Chicago — International Amphitheatre—Gallery—Space 16-17.



AMONG the refinements found on the new Buda engine models are practical features which further advance the effectiveness of its widely-favored lubricating system and which eliminate oil leakage.

For instance, the geared oil pump (A) is located at the center of the oil reservoir, thus permitting Buda engine operation on up or down grades without danger of starving the oil pump supply.

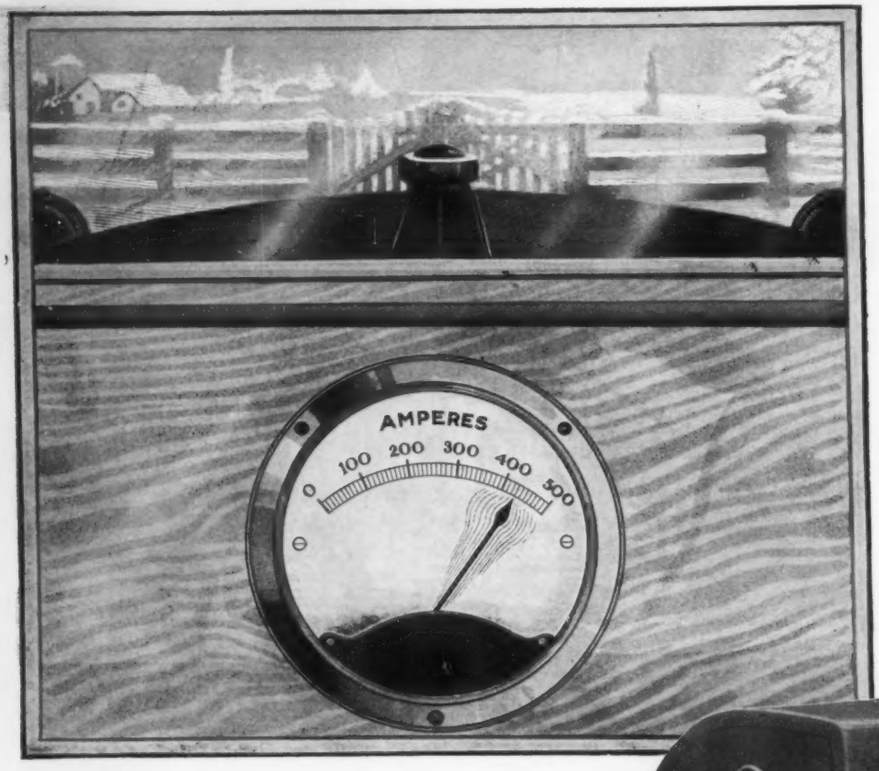
Then an extra wiper ring (B) fitted on the lower end of the Buda piston prevents an excess of oil reaching the combustion chamber, and a double throw oil ring (C) at the rear end of the crank shaft effectively prevents oil leakage into the bell housing.

That Buda engineers, with practical refinements, have kept well apace of progress in the automotive industry is no more significant than the fact that they constantly strive to build an engine having the highest performance quality attainable.

THE BUDA COMPANY, *Harvey* (CHICAGO SUBURB), *Ill.*
ESTABLISHED 1881

The latest Buda engine features will be on view at the New York Truck Show, Space 11, 12, 13, and at the Chicago Motor Truck Show, Space 26, 27, 28. Also the Boston Truck Show, the Kansas City Tractor Show and the Minneapolis Tractor Show. A really cordial welcome awaits you at the Buda booth.

BUDA
The
ENGINE

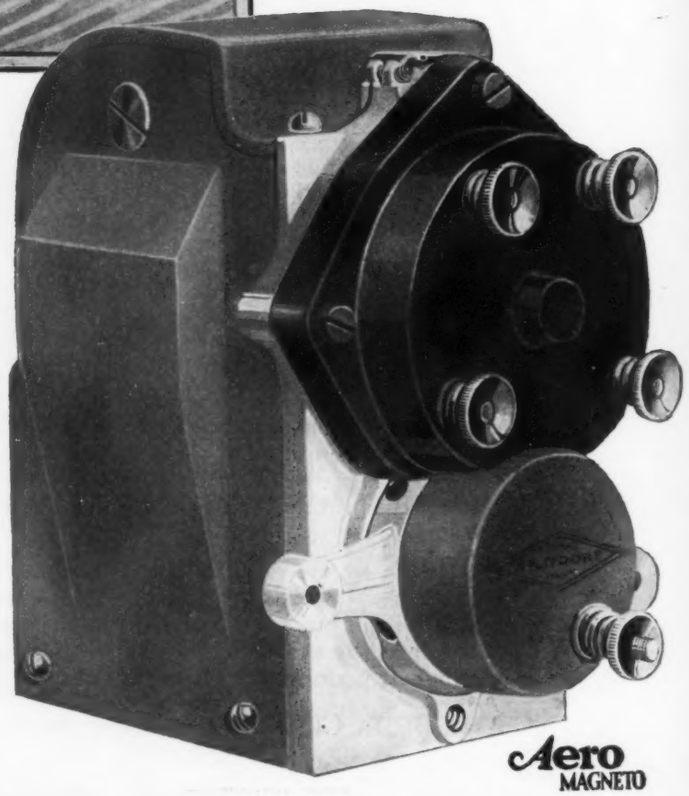


In cold weather-

with the battery discharging as high as five hundred amperes while turning over the starter, very little juice is left for an ignition system.

Gasoline will not vaporize rapidly in a cold engine and a fat hot spark is needed to ignite raw gas.

The Splitdorf Magneto, which generates its own current, does not depend on a battery. It is an entirely independent ignition system. The same hot spark is delivered at all times and under all conditions.

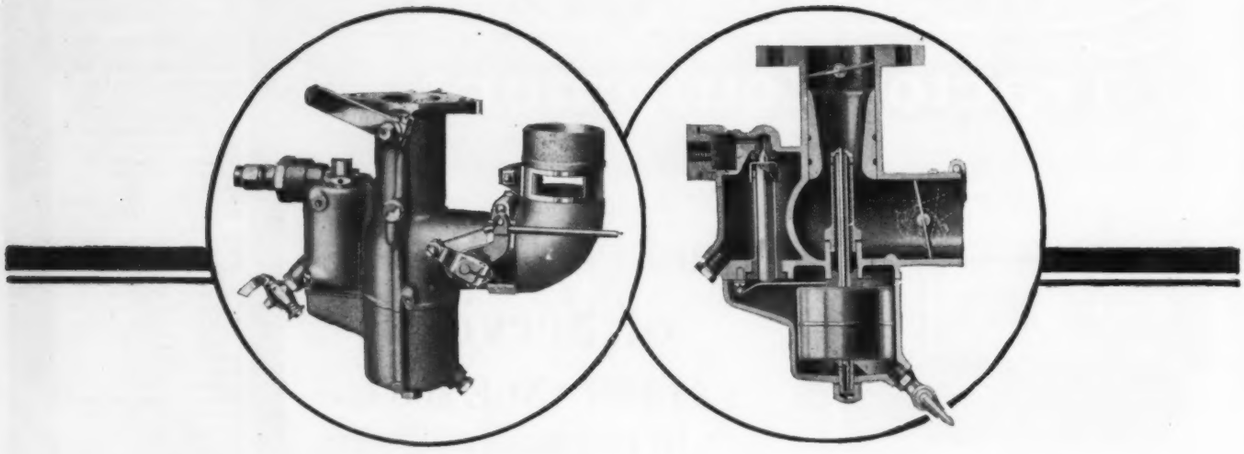


SPLITDORF
Electrical Co., Newark, N.J.
Sumter Division, 1466 Michigan Ave. Chicago

TRADE SPLITDORF MARK

Manufacturers of AERO, SUMTER and DIXIE Magnetos, Oscillating Magnetos and Impulse Starters

Rayfield Announces Model O Plain Tube Carburetor for Trucks



After spending more than two years studying the needs of manufacturers we have developed the Rayfield Model O plain tube carburetor for trucks.

Repeated tests on many makes of trucks both light and heavy have convinced us that Model O will show a record of performance in the truck field fully equal to the superior performances of other Rayfield models in the passenger car field.

This truck carburetor is of concentric float construction with a plain tube. The float mechanism is of the fulcrum lever type and provides for a positive method of controlling the flow of gasoline into the carburetor.

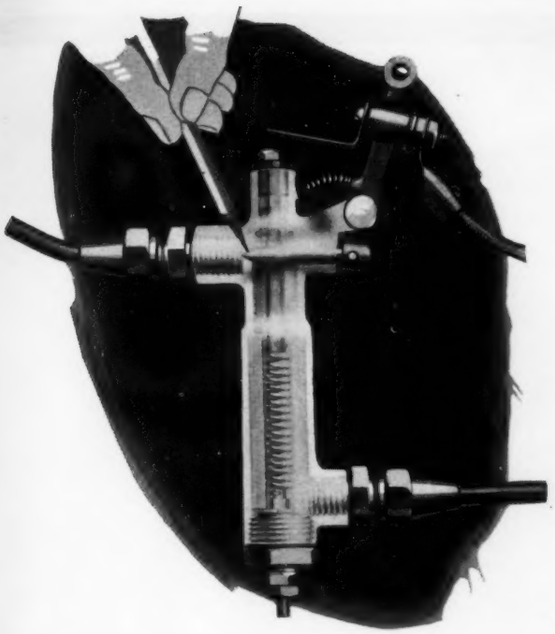
We are now in production on this carburetor. Samples for testing purposes will be sent to any responsible truck manufacturer.

We know that it will pay you to give Model O a trial before placing your contracts for next season's requirements.

BENEKE & KROPF MANUFACTURING CO.

21st and Rockwell Sts., Chicago, Illinois

RAYFIELD CARBURETORS



How Monel Metal Is Used to Make a *Permanently* Perfect-Fitting Needle Valve

It was vitally important that this needle valve should operate perfectly, and that this perfect operation should be **permanent**—for only by permanently perfect operation could this needle valve, which is a part of the Master Electrical Primer, overcome the chief prime objection.

This objection, as is well known to automotive engineers, has always been that a primer "interferes with carburetor adjustment."

LEAKAGES

The reason some primers are said by engineers to interfere with carburetor adjustment is because these primers are declared to leak.

If the primer outlet could be so constructed that it would always remain a perfect fit, carburetor adjustment would be done away with.

The manufacturers of the Master Electrical Primer, after searching for the best metal for some time, finally selected Monel Metal for the construction of the valve needle. Monel Metal is far harder than steel and rust proof, and the brass seat cannot cut a ring around the valve needle. At the same time the point of the valve needle is so large and the valve needle itself so long that it readily takes up any slight wear there may be on the brass seat.

In other details the manufacturers of the Master Electrical Primer has exercised the same thorough carefulness. The resistance coil is of Nichrome Alloy, for the use of which a royalty must be paid.

PRIMER DURABILITY

The spring which governs the electrical-connection arm and the gasoline outlet valve is particularly powerful and so durable that it will keep these parts working perfectly year after year, long after the motor car which it equips has been junked.

The efforts which have been expended to make the Master Electrical Primer permanently perfect are meeting with the reward which always comes to merit. Such companies as the manufacturers of National, Franklin and Cunningham motor cars have adopted the Master Electrical Primer as standard equipment, and from the many tests now being carried on by some of the most prominent manufacturers it is extremely probable that some others of the most prominent makers of cars in the United States will have adopted this primer as standard equipment.

We will gladly send you Master Electrical Primers to test out on your experimental models this winter.

THE MASTER PRIMER CO.
34 East Larned St. Detroit, Mich.

The Master Electrical Primer takes the gas directly from the carburetor, vaporizes it by passing it through the electrical coil and shoots the rich hot mixture thus made into the manifold, where it explodes on the first spark. The Master Electrical Primer is guaranteed to start any car in below zero weather inside seven seconds,—no matter how cold the motor.

MASTER ELECTRICAL PRIMER
"HEATS YOUR GAS SO IT MUST EXPLODE ON THE FIRST SPARK"

Type "G" Heater installed in Sedan

Type "A" Heater installed in Coupe

Type "DWS" Heater installed in Sedan

Cars using PERFECTION MOTOR CAR HEATERS as Standard Equipment on one or more models:

Allen
Case
Cole Aero-Eight (all models)
Crow-Elkhart
Grant
Haynes
Hudson
King
Kissel
Liberty
Maibohm
Mitchell
Moon
National
Northway Motors Corp. (truck cabs)
Oakland
Oldsmobile
Paige
Premier
Roamer
Scripps-Booth
Stephens Salient Six
Templar
Velie
Westcott
Willys-Knight
Yellow Taxicabs of Chicago.

Perfection Motor Car Heaters—an Essential Feature of Motor Car Equipment.

Perfection Motor Car Heaters are now an essential feature of motor car equipment.

Twenty-six motor car manufacturers have standardized on Perfection Motor Car Heaters as equipment for both open and closed bodies or for truck cabs.

Perfection Motor Car Heaters have many detailed improvements this year. They are efficient in operation and easy to install.

Our production since moving into our new factory is 600 heaters per day.

Let us help you work out the best possible installation for your cars.

The Perfection Heater & Manufacturing Co.
6545 Carnegie Ave. **Cleveland, Ohio**

At the New York Show, Jan. 3 to 10, 1920.

PERFECTION MOTOR CAR HEATERS

At the Chicago Show, Jan. 24 to 31, 1920.

All Victorious

BOSCH

VICTORIES in business, like victories in war are won through strength, courage and superior equipment. Dealers win their Sales battles easily when their products are equipped with Bosch High Tension Magneto Ignition. The Bosch gives them predominating prestige because it has proved supreme in every field. It is one of the most dependable, economical and efficient ignition systems known.

The force of Bosch Prestige and Bosch Advertising behind your selling efforts is a wonderful help.

And remember that nearly three hundred Bosch Service Stations are ready to serve your patrons.

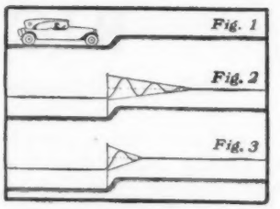
AMERICAN BOSCH MAGNETO CORPORATION

Main Office and Works—Springfield, Mass. *Branches*—New York, Chicago, Detroit, San Francisco—300 Service Stations in 300 Cities

Be Satisfied Specify Bosch

AMERICA'S SUPREME IGNITION SYSTEM

MOTOR TRUCKS - TRACTORS - AIRPLANES - MOTOR CARS - MOTOR BOATS - MOTORCYCLES - GAS ENGINES - ETC.



Example of How the Hartford Shock Absorber Works:

Fig. 1—Automobile approaching road bump.

Fig. 2—Movement of car body when car not equipped with Hartfords meets bump.

Fig. 3—Movement of car body when car equipped with Hartfords meets bump. Note how the Hartfords dampen the vibrations of the springs by absorbing the energy of spring movement, saving you from discomfort and protecting your car.

How Long Will Your Car Stand This?

Every hole or bump in the road deals your car a telling blow. Every time the springs are moved, there is contrary reaction that generally racks your car and jolts the passengers.

Automobile manufacturers have spent thousands trying to design springs that would always protect their cars. They give you the best—*but that is not enough.* Spring-action must be regulated. Harmful reaction must be absorbed. Wheels must be kept on the road.

The Hartford Shock Absorber regulates the springs on both compression and expansion. It protects your car from rapid deterioration and your friends from discomfort.

The Hartford is now a part of the factory equipment of many of America's fine cars. These cars have the best of everything—yet they realize that the Hartford is indispensable.

We invite your engineers to test Hartfords on your make of automobile. Every car manufacturer can easily prove for himself that the Hartford Shock Absorber is a paying investment as initial equipment. Write for details.

The manufacturers of the following cars are protecting them, and insuring riding comfort to their owners, by factory-equipping their product with Hartford Shock Absorbers:

Apperson	Mercer
Argonne	Murray
Biddle	National
Cole	Owen-Magnetic
Crawford	Premier
Daniels	Revere
Marmon	Singer
McFarlan	Stutz

Hartford
SHOCK ABSORBER

EDWARD V. HARTFORD, Inc. **35 Warren Street, New York City**

Factory Branches—Boston, 319-325 Columbus Ave.; Chicago, 1716 Michigan Ave.

The Prestige of the Pioneer

Occasionally it happens that the pioneer in a certain field of human effort comes down the years with his leadership still unchallenged.

The pioneer is still the standard bearer. His leadership has become an institution. Men take for granted that his mature experience, his senior skill in his field will continue to give maximum merit to the thing he makes or does.

Prestige orders further progress. The whole public he serves, even his contemporaries, give generous recognition as each year the pioneer-leader meets that responsibility.

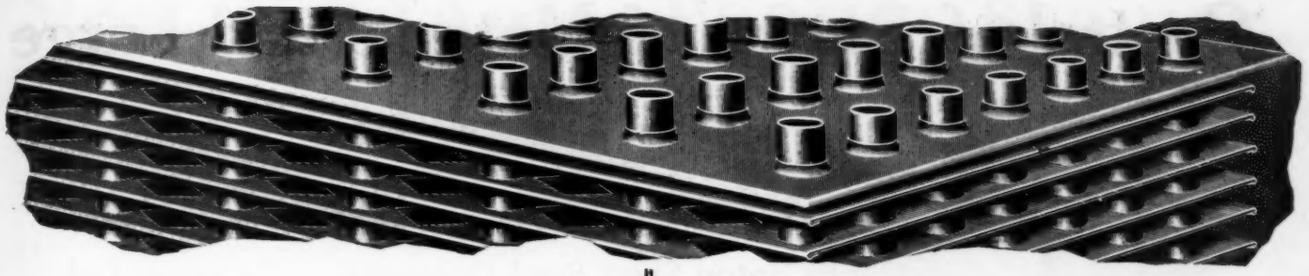
Delco enjoys the distinction of having been the first Starting, Lighting and Ignition System for motor cars,—as Cadillac enjoys the distinction of having been the first motor car to install it.

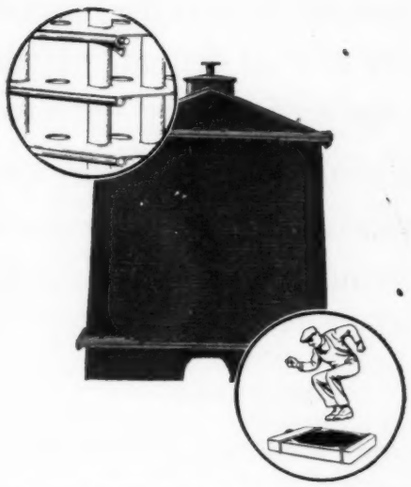
Each year since, because Delco has steadily maintained its leadership, Delco has been standard equipment on Cadillac cars.

Manufacturers of high-grade motor cars willingly pay more for Delco, not for the prestige which surrounds its name but for the quality with which Delco steadily increases that prestige.

Delco

Starting, Lighting and Ignition Systems





The continuous fin tubular type of radiator core construction is especially strong because the front edge of each horizontal fin is reinforced with a heavy steel wire.

Main plant and general offices.

Vibration does not affect the radiator of the continuous fin tubular type

The two essential parts of this type of radiator core are the horizontal cooling fins and the vertical water tubes.

The function of the fins is to conduct the heat from the water in the tubes and dissipate it by convection to the rushing cool air. In addition to that the fins stabilize the tubes.

In the tubes the water flows freely and unimpeded. There are many tubes, placed in rows, serving also as braces to the horizontal fins.

To further strengthen the fins and to increase their resistance to blows, each is reinforced along its front edge with a steel wire. The stress of a bump is resisted not entirely at the point of contact, but throughout the entire core. Ordinary blows have no damaging effect.

Free passage of air—another distinctive feature of the continuous fin tubular type of radiator core. Practically no impediment is offered to the circulating cold air, the open passageway permits of quick exhaustion of the heated air, causing the circulation of an unusually large volume of cold air.

Since the beginning of the motor car industry this company has manufactured radiators of every type—both tubular and cellular. By conducting exhaustive tests and closely watching the performance of the various types we are firm in our conviction that the continuous fin tubular type of radiator is superior for truck service. Obviously, our only reason for taking such a positive stand is for the insurance of greater cooling efficiency and dependability.

McCord Manufacturing Company, Inc.
Detroit, Michigan

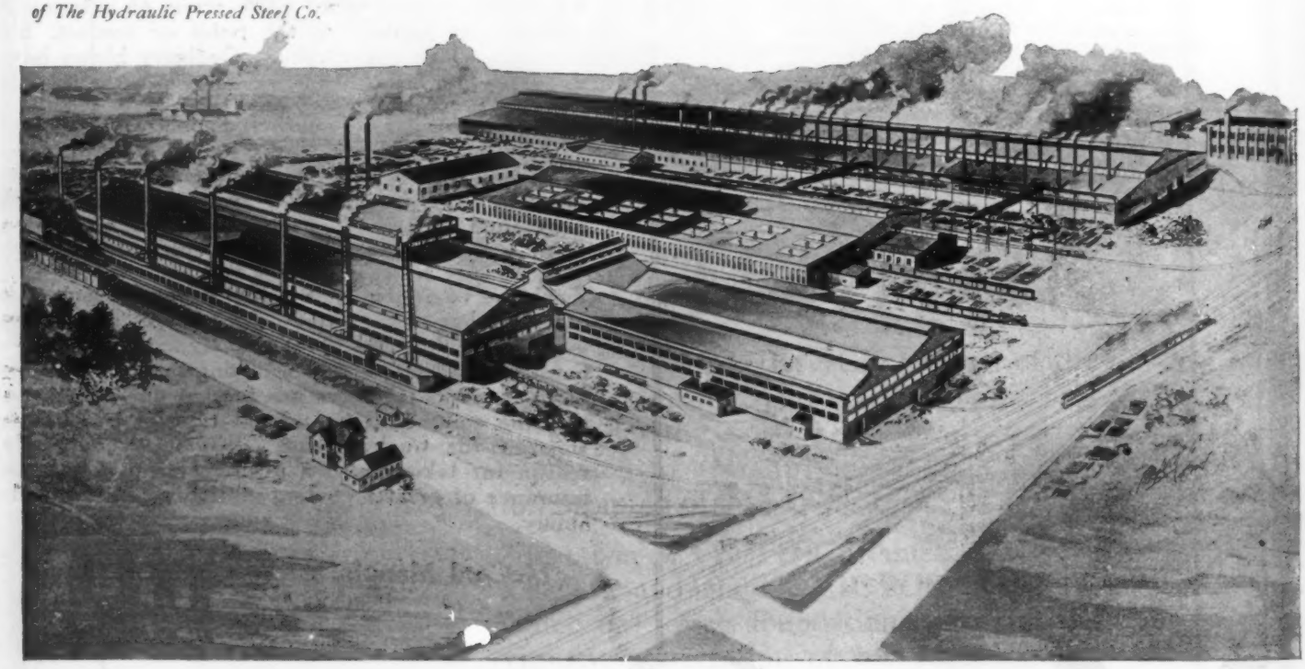
McCORD
RADIATORS

Control of Source of Material and Large

Hydraulic steel comes from its own source of supply, the Canton Sheet Steel Company. The control of the raw material source is an important factor in frame requirements. It not only insures the standard of product but the quality of steel desired. It also has a direct bearing on the service to be rendered.

Large warehouse space at the Hydraulic Plant, with a constant incoming supply of steel, keeps the stocks far beyond anticipated requirements. Linked up

Plant of The Canton Sheet Steel Co. of The Hydraulic Pressed Steel Co.



HYDRAULIC

Steel Stocks Assure PROMPT SERVICE

with this is the rigid Hydraulic inspection of materials and of product.

These are some of the features in the complete service which Hydraulic renders.

Manufacturers of

Pressed Steel Frames for Passenger Cars, Trucks and Tractors; Axle Housings; Brake Drums; Torque Arms; Running Boards; Step Hangers; Hub Flanges; Discs; Dust Shields; Sprockets; Steel Barrels; Aeroplane and Miscellaneous Stampings.

THE HYDRAULIC PRESSED STEEL COMPANY
CLEVELAND, OHIO

Branch Sales Offices:

New York	Chicago	Detroit
Singer Building	Fisher Building	Book Building

"MORE Than a Place to Work"

"Responsibility produces self-respect and increases pride in accomplishment. At Hydraulic every man has a definite responsibility. Our own men have adopted the slogan—Hydraulic is 'MORE than a Place to Work.' This spirit is reflected in the quality of Hydraulic products."

Glimpses of the Receiving and Stock Yards of The Hydraulic Pressed Steel Co.

PRESSED STEEL COMPANY

Positions & Men Available

The following announcements are published for the benefit of members of the Society and the convenience of companies in need of men. No charge whatever is made for this service. In the case of items prefixed by an asterisk further information is withheld at the request of the company or individual making the insertion, but written communications bearing the number of such items will be forwarded by the S. A. E. Office. In other cases further information will be supplied by the Office of the Society. Applications for positions from non-members must be endorsed by a member of the Society.

0673 MECHANICAL AND AERONAUTICAL ENGINEER, age 30, engaged in the following capacities in the automotive field, assistant experimental engineer, chief engineer, sales engineer, sales and advertising manager. Exceptional record for the production of results. During the war was an aviator and aeronautical research Army officer. Desires to connect with a reputable company in an executive or sales capacity.

0727 MECHANICAL ENGINEER, technical graduate, competent to take charge of design, development or production on trucks or tractors, desires position as assistant to chief engineer or to production manager with truck or tractor builder. Age 28.

0729 EXECUTIVE IN MANUFACTURING Has had charge of organizing factories for production of the highest class automobiles and airplanes. Has practical experience in modern production methods, engineering and costs. Available for position as general or works manager. Has initiative and ability to introduce new and effective methods or to reorganize a plant to meet the present business conditions.

0730 ENGINEER OR PRODUCTION MANAGER with eighteen years' motor car and tractor experience, eleven years in executive positions, now Army officer in Ordnance Department. Any position considered with progressive or new company offering good opportunity now or in the future. Age 38.

0731 MECHANICAL ENGINEERING GRADUATE, four years as designing engineer on high-grade custom car, handling entire work in developing new models, desires a position. Thoroughly competent to design and lay out high-grade engines and chassis. Has practical shop and production experience. Age 27.

0732 ENGINEERING EXECUTIVE, recently demobilized captain Aircraft Production, graduate of University of Wisconsin, desires position as assistant to factory manager or production engineer or in executive capacity with progressive manufacturer of automotive products. Capable of handling all details. Available at once.

0733 PRODUCTION AND EXECUTIVE ENGINEER, technical graduate with twenty-two years' practical experience in shop and design of automobiles, tanks, tractors, internal-combustion, Diesel and semi-Diesel engines, who understands economic shop management and production, desires position with company which needs high-class executive. At present is officer Ordnance Department as armament inspector and shop executive.

0734 MECHANICAL ENGINEER with seven years' tractor experience, who understands costs and practical design,

(*Continued on page* 52)

POSITIONS & MEN AVAILABLE *Cont.*

Men Available (Continued)

desires position as chief engineer or research engineer with progressive tractor firm. Available Oct. 1.

0735 GRADUATE MECHANICAL ENGINEER, age 31, desires position preferably in Middle West. Experience for past eleven years has been broad and along lines proving executive ability as well as success in handling engineering and production problems.

0736 MECHANICAL ENGINEER with extensive experience on automotive engines and farm tractors would like to connect with an aggressive tractor company as chief engineer. Formerly chief engineer of a prominent tractor company. Thoroughly familiar with modern shop methods. Age 32.

0737 MECHANICAL ENGINEER, university graduate, 27 years of age, five years' shop and design experience in automotive work, with ability and energy, desires assistant engineer or similar position.

0738 TECHNICAL GRADUATE Mechanical engineer, with ten years' experience on design of high-class motor cars, airplane motors and airplanes. In Government air service during war. Position as chief engineer or assistant. Location in Detroit preferred.

0739 PRODUCTION ENGINEER, expert machine-tool designer, 28 years of age, single, would like to connect with engineering firm on road. Has A-1 record.

0742 DESIGNER AND LAYOUT MAN, experienced on motor, generator and gasoline engine design, desires position with a chance for advancement. Age 25; married.

0744 ENGINEER, 31 years of age, married, ten years' experience in factory, service, sales and executive capacities, including export experience, graduate in law, desires an opening where extensive experience in the motor-car industry, legal training and constructive ideas will be advantageous. At present first lieutenant in the Air Service.

0745 INDUSTRIAL ENGINEER with eight years' experience who can show results wishes to secure permanent location in the automotive field as superintendent or engineer in charge of betterment work.

0748 PRODUCTION MANAGER Former Ordnance Department officer, good executive, with fifteen years' general automotive experience in design, testing and production of interchangeable parts, desires position with assured future in either automotive field or production of metal specialties.

0749 EXECUTIVE, experienced in factory management, production, engineering and inspection work in airplane, automobile and steam turbine fields is available for position. Thirty-nine years of age, married. Industrious, judicious and possesses good initiative. Prefers Eastern section, but well acquainted with business in the Middle West.

0750 ENGINEER Technical graduate with good executive ability desires employment with a progressive firm manufacturing automobiles or accessories in the purchasing or production departments. Recently production manager of large aircraft factory.

0755 SUPERINTENDENT OF TRACTOR FACTORY, now employed, desires to change to a larger company offering greater

(*Continued on page* 54)

*See announcement at the head of the "Positions and Men Available" column, page 50.

POSITIONS & MEN AVAILABLE *Cont.*

Men Available (Continued)

opportunities of advancement in the tractor field. With present company six years. Eighteen years' practical and executive experience covering general mechanical and tractor engineering in design, experimental and production lines. Has specialized on the track-laying type of tractor. Capable of handling any or all departments of a factory. Salary open; location immaterial.

0756 MECHANICAL ENGINEER Technical graduate with two years' experience in powerplant operation, fuels and refinery practice and two years' experience in airplane design desires position with private concern where future depends upon ability. At present employed by Government on aircraft work.

0757 MECHANICAL AND CIVIL ENGINEER with five years' practical experience in mechanical drafting, engineering, manufacturing and purchasing wishes a position with manufacturer where an opportunity will be given for advancement. Technical graduate, 28 years of age.

0758 GRADUATE ENGINEER, mechanical and electrical, with ten years' experience in experimental work and inspection with special attention to aiding production by changes in design and shop practice. Also thoroughly competent to outline and conduct tests of engineering materials and apparatus and to report on and interpret results clearly and accurately.

0759 ENGINEER with several years' experience in the development of gasoline engines, especially aviation types, who has held very responsible positions with the Government the last two years now desires to locate with a private firm building internal-combustion engines. Capable of taking complete charge of testing and development work.

0762 ENGINEER University graduate, experienced in passenger car and truck engineering, designer of several successful engines, desires position with some company where high-grade engineering ability is required. Competent to take charge of engineering design and experimental work. Particularly interested in the light-weight car.

0763 FOREIGN REPRESENTATIVE Factory superintendent with sixteen years' experience in internal-combustion engines and automobile accessories intends to visit England and desires to represent a reliable company in the automotive field. Will consider trip to South America or Mexico. Has good knowledge of Spanish.

0764 DIRECTOR OF PURCHASES with twelve years' purchasing and engineering experience desires to make a new connection. Has a thorough knowledge of trade conditions and sources of supply. Is able to judge material from an engineering and manufacturing standpoint as well as from the price viewpoint. Age 32, married.

0765 ENGINEER Capable of taking entire charge of engineering department, 39 years old, a technical graduate, fourteen years' experience in the design and manufacture of automotive engineering work, including air-cooled engines, the last few years as chief and consulting engineer. Resourceful, capable of initiating improvements, carrying out development work and finishing designs for quantity production.

(*Continued on page* 56)

*See announcement at the head of the "Positions and Men Available" column, page 50.

POSITIONS & MEN AVAILABLE *Cont.*

Men Available (Continued)

0768 EXPERIMENTAL ENGINEER wishes to locate with an Eastern automobile company. Has also had a number of years of service work and miscellaneous experience as an officer in France.

0773 TECHNICAL MAN with eleven years of practical experience on gasoline engines, accessories and automatic machinery, seeks position with well-established New York company. Has a thorough knowledge of engineering subjects and modern methods of production.

0774 MECHANICAL ENGINEER with eight years' experience in general engineering work and automobile manufacturing, desires position as an engineer or technical representative in the automotive field.

0775 DESIGNING AND PRODUCTION ENGINEER with eleven years' experience. Age 28, married. Technical and practical executive with initiative and good record, experienced in designing and planning of high-grade machinery and tools. Good organizer, tactful in handling men. Had charge of important Government work with private firm during war. Available at once.

0776 EXECUTIVE ENGINEER, age 25, is open for engagement with progressive organization. Good executive and able to handle men. Has had exceptional experience in mathematical designing, drafting, production and order departments, estimation of raw material requirements, powerplant tests, maintenance, plant efficiency, general accounting and business methods. Salary $4,000.

*0777 BEARINGS ENGINEER desires to hear from parts makers or others contemplating the manufacture of roller bearings.

0778 GRADUATE MECHANICAL ENGINEER, age 39, with nine years' European and eight years' American experience as chief draftsman, superintendent, chief engineer and factory manager of automobile companies. Last six years in present position as executive technical manager of well-known automobile manufacturing company in neutral country, building cars on American principles. Speaks English, French and German fluently. Desires to get in touch with passenger car or truck building company wishing to organize and develop European interests.

0779 EXECUTIVE experienced in production and designing engineering with experience also in sales and advertising on farm lighting plants, marine engines and motor vehicles. Six months in charge of several thousand motor vehicles in France.

0780 EUROPEAN REPRESENTATIVE Chief engineer with European education, Danish, French, German, and ten years' broad and successful American experience in leading position with first-class firms in the automotive industries, wishes to connect with an American firm, desirous of obtaining as its European representative a capable, honest and ambitious man, with a knowledge of European conditions as well as especially good connections in the Scandinavian countries, where the interest in American products, at the present, is extremely keen, an exposition of American goods, exclusively, being scheduled to take place at Copenhagen, in the early part of 1920.

*0781 MECHANICAL ENGINEER of high standing, experienced four-wheel-drive designer and manufacturer with a broad experience and successful record, is open for new engagement with the intention of developing and

(*Continued on page* 58)

*See announcement at the head of the "Positions and Men Available" column, page 50.

POSITIONS & MEN AVAILABLE *Cont.*

Men Available (Concluded)

manufacturing a new line and type of high-speed motor trucks and road transportation tractors of the four-wheel-drive design.

0782 PRODUCTION MAN with ten years' experience in drafting and designing storage batteries, starting and lighting systems, trucks, tractors and aviation engines, desires to make a change to go into production work where initiative and tact will be appreciated.

0783 CHIEF ENGINEER with eight years' experience in manufacture of frames and stampings for automobiles, trucks and tractors, wishes to make new connection. Preference is for a sales position where engineering ability will be of advantage. Has shop experience and technical training and knows automotive and general mechanical construction.

0785 ASSISTANT ENGINEER, desires experimental or research work in New York or immediate vicinity. Age 34.

0786 GRADUATE ENGINEER with twenty-two years' experience in steam, electrical and automotive lines, seeks permanent connection with reliable company, extreme East or West. Speaks French and German. Now truck engineer in Chicago.

0787 EXECUTIVE POSITION desired by practical mechanic with sixteen years' experience in the manufacture of machine and precision tools and automotive parts and a thorough knowledge of the efficient operation of all machine tools.

POSITIONS AVAILABLE

625 OHIO AUTOMOBILE MANUFACTURER has openings for aggressive, well-educated young men capable of developing into executives and willing to start at modest salary. State age, height, weight, married or single, education, experience, knowledge of mechanical drafting and blueprint reading, service record, present salary, salary expected at start, whether any dependents, and if preference is for purchasing, sales, accounting, engineering or production.

636 SALESMEN experienced in selling batteries and installing service stations desired by Eastern manufacturer. Previous road selling experience required and good knowledge of batteries, service station equipment and installation.

660 HIGH-GRADE SALESMAN, experienced in automotive equipment, ignition and lighting systems and automobile accessories, needed by Eastern accessory concern to travel in Latin-America and West Indies. Must have good business training and knowledge of Spanish.

704 ELECTRICAL REPAIRMEN on automobile starting motors and generators desired for Eastern service stations.

*707 SALES ENGINEER to call on trade desired by Indiana parts manufacturer. Prefer one with some bearing experience.

731 MECHANICAL DRAFTSMEN with technical training, preferably with motor truck or automobile experience.

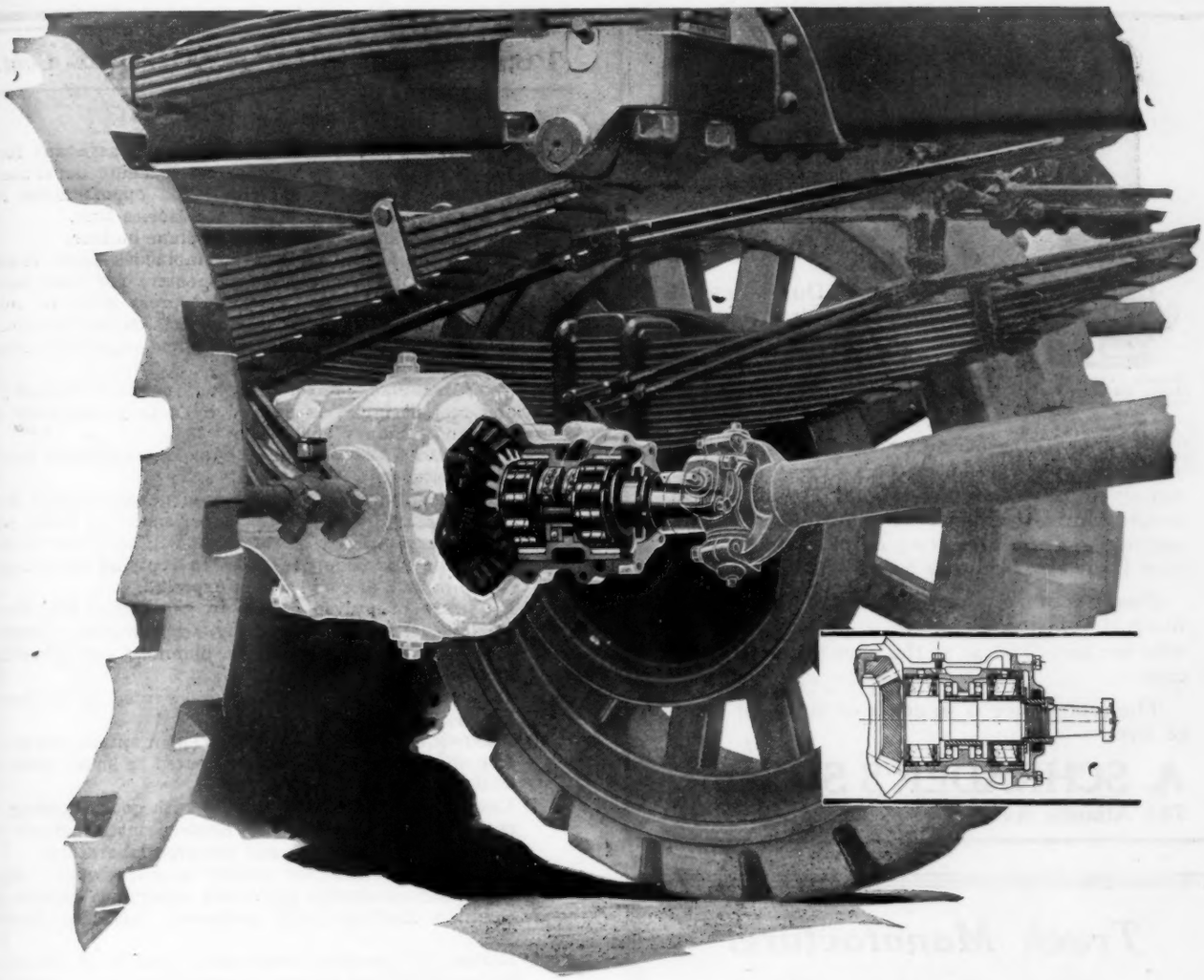
735 DESIGNER WITH PRODUCTION EXPERIENCE in electric lighting and starting systems is desired by prominent Philadelphia manufacturer. Applications should be typewritten. Give education, detailed experience, age, present and expected salary.

*736 MECHANICAL ENGINEER, experienced in automotive field, with knowledge of pressed steel manufacturing preferred. Splendid opportunity for man with ability and initiative, in large organization. Location Middle West.

737 AERONAUTIC DRAFTSMEN Permanent positions. Location near New York City.

(*Continued on page* 60)

*See announcement at the head of the "Positions and Men Available" column, page 50.



This Rugged Hyatt Pinion Shaft Mounting

Withstands Perfectly the Radial Loads and Thrust of Hard Service

The pinion shaft, too, calls for a rugged bearing assembly able to take the radial and thrust loads resulting from driving power and gear tooth pressure—the sudden working loads on the drive shaft.

To withstand the constant abuse of such a location, the above mounting with two heavy duty Hyatt Bearings at the points of greatest punishment supplemented by suitable thrust bearings, cannot be surpassed.

Trouble free — non-adjustable because adjustment is never needed with a Hyatt—such a Hyatt-equipped pinion quietly performs its function without care or attention throughout the entire working life of the motor truck.

Hyatt Roller Bearing Company, *Motor Bearings Division*, Detroit, Michigan

HYATT QUIET BEARINGS

POSITIONS & MEN AVAILABLE *Cont.*

Positions Available (Continued)

743 FOREMAN PUNCH PRESS DEPARTMENT, assistant foreman automatic and hand screw machine department and assistant chief inspector. A-1 opportunities for first class men with Chicago accessories firm.

771 DETAILER wanted by Eastern airplane builder.

*773 Instructors needed for newly established Motor Transport School. Blacksmiths, carpenters for body work, tire experts with knowledge of press work or solid tires, engine men and chassis experts on transmissions, clutches and differentials, and a few experts on sheet metal and radiator work.

*789 TOOL DESIGNER, competent to hold position of chief jig and tool designer, is desired by a large company in England. Salary $5,000.

799 PRACTICAL CHEMIST wanted by a Massachusetts fabric manufacturer.

*805 TOOL DESIGNERS wanted by a large automobile firm located near Detroit. Men experienced on tools, jigs and fixtures desired. Preference will be given to men who have had shop practice. In replying state experience in full, age and wages expected.

810 ENGINEER of proved ability in gas engine and farm tractor designing desired by Ohio engine concern. Must also be experienced in planning and directing production.

811 ENGINEER to specialize on trucks wanted by St. Louis automobile company.

812 FIRST-CLASS LAYOUT AND DETAILER on automobile truck axle work needed by concern located in small town in western Michigan.

815 ENGINEER A technical graduate with good standing in mathematics is desired by Eastern manufacturer to assist in drafting room and research laboratory.

818 CHIEF DRAFTSMAN for trailer manufacturer Man with good automobile and truck experience capable of handling drafting room preferred. Location Middle West.

852 EXPERT AUTOMOBILE DRAFTSMAN, capable of assisting the engineer and taking charge of details. Location Connecticut.

853 EXPERT MECHANICAL ENGINEER for work with Detroit truck builder.

854 HIGH-GRADE SUPERINTENDENT desired by motor truck builder. Location Detroit.

855 DESIGNING DRAFTSMEN desired for layout work on ordnance and tractor work. Location Illinois.

856 ASSISTANT ENGINEER technically trained man with practical experience in the designing of automobile engines and tool fixtures for maximum production preferred. Good opportunity for right man. Location Wisconsin.

857 DETAILERS AND LAYOUT MEN on truck and tractor parts. Location Indiana.

858 MECHANICAL DRAFTSMEN for New Jersey machine and tool manufacturer.

859 DRAFTSMAN accustomed to layout and detail work on small valves, fittings and screw machine parts. Experience need not be extensive, but prefer man who can work up to a position of responsibility. Location New Jersey.

860 TRACTOR MEN, designing engineer, checker, estimator and draftsmen. Location Illinois.

861 TRUCK DESIGNERS for established tractor builder. Location Illinois.

862 TOOL DESIGNERS capable of designing jigs, tools and fixtures for economical manufacture. Prefer men who are up-to-date and progressive in methods and practical. Location Illinois.

(*Continued on page* 62)

*See announcement at the head of the "Positions and Men Available" column, page 50.

POSITIONS & MEN AVAILABLE *Cont.*

Positions Available (Concluded)

863 DESIGNERS of electric industrial trucks. Men who have had broad experience in this line and who are qualified to grow into bigger positions. Location Massachusetts.

897 CHIEF INSPECTOR, executive capable of taking charge of inspection department of Cleveland passenger car builder.

898 CHECKER AND LAYOUT DRAFTSMEN desired by New York State truck builder.

899 DRAFTSMAN with a thorough knowledge of the design and manufacture of small motors, generators and mechanical appliances, with experience in factory methods of manufacture, detail drafting, design and checking. Location New York City.

900 SALES MANAGER One who has had training as assistant to a successful motor truck sales manager. Must be a practical and experienced truck man with executive and organizing ability to build up a dealers' organization and promote the sale of high-grade trucks.

901 AERONAUTICAL DESIGNERS with at least two years' experience in checking and layout work on automobiles and engines desired for Government work. Location Ohio.

902 SALES ENGINEER A young man with sales and engineering ability is wanted for sales department of large wheel company. Location Indiana.

903 LABORATORY ENGINEER by a large Detroit automobile company. Young man with natural mechanical ability and college education for laboratory research work preferred. Experience in dynamometer operation desirable. A good opening for a man having initiative and willingness for hard work. State all details regarding previous experience in application.

904 TRUCK ENGINEER experienced in the construction of bodies and appurtenances incidental to the application of bodies to the trucks. Young man with development experience preferred. Good opportunity for advancement. Location Ohio.

905 MATERIAL SUPERVISOR experienced in requisitioning material used in factory departments, receiving stores and shipping department, to take complete charge of all materials throughout the plant. Location eastern New York.

906 METALLURGIST for Middle West plant doing case hardening of small parts. A technical man with some experience and exceptional ability for getting things done.

907 YOUNG TECHNICAL ENGINEER for shop executive position. A man with real possibilities who is seeking an opportunity to demonstrate his ability. Experience not of the greatest importance as it is expected to give him proper training. In application state education and accomplishments and include a small photograph if possible. Location Indiana.

908 ASSISTANT CHIEF ENGINEER or chief draftsman for New Jersey engine builder.

909 MACHINE TOOL DRAFTSMAN with good experience. Location eastern New Jersey.

910 MECHANICAL DRAFTSMEN by an Ohio builder of an air-cooled engine. Young men are desired who appreciate the advantages to be gained by experience and willing to consider the educational value in connection with a moderate salary. Some technical education necessary.

911 CHIEF DRAFTSMAN with experience in this line desired by airplane builder located near New York City.

912 SHOP SUPERINTENDENT with experience in manufacture of Diesel and heavy type engines. Location Missouri.

913 YOUNG EXECUTIVE ENGINEER to act as assistant to consulting engineer. Location New York City.

*See announcement at the head of the "Positions and Men Available" column, page 50.

Built for strength and endurance

FOR nearly four years Thermoid-Hardy Universal Joints have stood the most drastic tests on every type of automobile from the lightest passenger car to the heaviest truck. They have given as high as 60,000 miles of continuous hard service without wearing loose or losing their valuable shock-absorbing qualities.

The Thermoid-Hardy process

The great strength and durability of Thermoid-Hardy Universal Joints are largely due to the patented process by which they are constructed.

The elastic discs are built up from layers of fabric woven from long strand Sea Island cotton. Each layer is impregnated with a special friction compound, which is driven into the mesh of the cloth by means of heavy steel rollers.

The fabric is then cut into squares and piled up fanwise in the well-known Thermoid-Hardy formation, so that the strands of cotton in each layer run in a different direction from those of the preceding layer. This insures a uniform strength and elasticity which can be obtained in no other manner.

The layers are finally welded together under hydraulic pressure until the disc becomes one compact, homogeneous mass, which is cured under heat to just the proper degree of flexibility. The completed disc has a tensile strength of 3400 pounds per square inch.

The layers are arranged fanwise, so that the strands of cotton in the various plies run in different directions. This patented construction gives the disc a uniform strength and elasticity which can be obtained by no other method.

The bolt holes are reinforced with fluted steel washers

Three separate discs are bolted together in one joint

Repair bills reduced

Manufacturers have found that repair bills can be greatly reduced by using Thermoid-Hardy Universal Joints. The elastic discs absorb the injurious shocks and vibrations which are intensified by old-fashioned metal couplings. The wear on shafting, gears, bearings and rear axle is thus minimized, and the life of the car prolonged to a marked degree.

Fifty leading manufacturers of passenger cars and trucks have adopted Thermoid-Hardy Universal Joints as standard equipment.

Send for our new book, "Universal Joints —Their Use and Misuse." It will give you details of construction, records of performance and opinions of leading engineers.

When you build a car with its drive shaft cushioned by Thermoid-Hardy Universal Joints, you build a more quiet running car —one with fewer come-backs for adjustment.

Thermoid-Hardy Universal Joints will make good or—WE WILL.

Thermoid Rubber Company

Sole American Manufacturers
Factory and Main Offices: Trenton, N. J.
New York Chicago San Francisco Cleveland
Detroit Los Angeles Philadelphia
Pittsburgh Boston London Paris Turin

THERMOID-HARDY UNIVERSAL JOINT

Fanwise construction for strength

Makers of "Thermoid Hydraulic Compressed Brake Lining" and "Thermoid Crolide Compound Tires"

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Standard Parts Co.

Airplanes
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United Aircraft Engineering Corp.

Ammeters
Nagel Electric Co., W. G.
Westinghouse Electric & Mfg. Co.
Weston Electrical Instrument Co.

Automobile Accessories
United States Auto Gear Shift Co.

Axle-Housings, Cast Steel
Standard Steel Castings Co.

Axle-Housings, Pressed Steel
Detroit Pressed Steel Co.
Hydraulic Pressed Steel Co.
Smith Corp., A. O.

Axles, Cold Drawn
Union Drawn Steel Co.

Axles, Front and Rear
Hero Manufacturing Co.
Park Drop Forge Co.
Savage Arms Corp.
Standard Parts Co.
Union Switch & Signal Co.
Williams, J. H., & Co.
Wyman-Gordon Co.

Babbitt Metal
Merchant & Evans Co.

Balls, Steel
Auburn Ball Bearing Co.
Marlin-Rockwell Corp.
New Departure Mfg. Co.
S K F Industries, Inc.

Bands, Brake
Lancaster Steel Products Co.
Raybestos Co.

Bands, Felloe
Jaxon Steel Products Co.

Barrels, Steel
Hydraulic Pressed Steel Co.

Bars, Bronze Cored
American Bronze Corp.

Bars, Iron and Steel
Interstate Iron & Steel Co.
Marlin-Rockwell Corp.

Batteries, Ignition, Lighting and Starting
Automotive Products Corp.
Electric Storage Battery Co.
Ericsson Mfg. Co.
Paul M. Marko & Co., Inc.
North East Electric Co.
Willard Storage Battery Co.

Batteries, Storage
Paul M. Marko & Co., Inc.

Battery Parts
Paul M. Marko & Co., Inc.

Beams, Channels and Angles
Interstate Iron & Steel Co.

Bearing Metal, Babbitt
Muzzy-Lyon Co., Ltd.

Bearing Metal, Bronze
American Bronze Corp.
Federal Bearing & Bushing Corp.

Bearings, Babbitt and Bronze
Doehler Die-Casting Co.
Federal Bearing & Bushing Corp.
Franklin Mfg. Co.
Muzzy-Lyon Co., Ltd.

Bearings, Ball
Auburn Ball Bearing Co.
Automotive Products Corp.
Bantam Ball Bearing Co.
Bearings Co. of America
Fafnir Bearing Co.
Federal Bearings Co.
Gurney Ball Bearing Co.
Marlin-Rockwell Corp.
New Departure Mfg. Co.
Norma Co. of America
Oakes Co.
S K F Industries, Inc.

Bearings, Ball Thrust
Bearings Co. of America

Bearings, Bronze
American Bronze Corp.
Federal Bearing & Bushing Corp.

Bearings, Graphite and Babbitt
Muzzy-Lyon Co., Ltd.

Bearings, Oilless
Arguto Oilless Bearing Co.
Bound Brook Oil-less Bearing Co.

Bearings, Roller
Automotive Products Corp.
Bower Roller Bearing Co.
Hyatt Roller Bearing Co.
Marlin-Rockwell Corp.
Norma Co. of America
Spicer Mfg. Corp.
Standard Parts Co.
Timken Roller Bearing Co.

Bells or Gongs, Mechanical
New Departure Mfg. Co.

Belting, Fan
Gilmer Co., L. H.
Graton & Knight Mfg. Co.

Belting, Leather
Graton & Knight Mfg. Co.

Belting, Link, Round and V
Graton & Knight Mfg. Co.

Belting, Rubber
Goodyear Tire & Rubber Co.

Belting, Silent Chain
Morse Chain Co.
Whitney Mfg. Co.

Blanks, Gear
Central Steel Co.
Park Drop Forge Co.
Standard Parts Co.

Boats, Flying
Curtiss Aeroplane & Motor Corp.

Bolts, Chassis
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Steel Products Co.

Bolts, Coupling
Steel Products Co.

Bolts, King
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Bolts, Spring
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Bushings, Oilless
Arguto Oilless Bearing Co.
Bound Brook Oil-less Bearing Co.

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Camshafts
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Park Drop Forge Co.
Savage Arms Corp.
Union Switch & Signal Co.
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Carbureters
Beneke & Kropf Mfg. Co.
Wilcox-Bennett Carburetor Co.

Carbureters, Gasoline
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Zenith Carburetor Co.

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Castings, Aluminum, Brass and Bronze
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American Bronze Corp.
Doehler Die-Casting Co.
Federal Bearing & Bushing Corp.
Franklin Mfg. Co.
Light Mfg. & Foundry Co.

Castings, Die
Acme Die-Casting Corp.
Doehler Die-Casting Co.
Franklin Mfg. Co.
Light Mfg. & Foundry Co.

Castings, Malleable Iron
American Malleable Castings Assn.
Hammond Malleable Iron Co.

Castings, Steel
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Chains, Anti-Skid
Rowe Calk & Chain Co.

Chains, Automobile Engine
Morse Chain Co.
Whitney Mfg. Co.

Chains, Block
Morse Chain Co.
Whitney Mfg. Co.

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Chucks, Quick Change
Whitney Mfg. Co.

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Williams, J. H., & Co.

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Cleaners, Waste
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Clutches
Borg & Beck Co.
C. A. S. Engineering Co.
Detlaff Co., A. J.
Hartford Automotive Parts Co.
Merchant & Evans Co.

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Bantam Ball Bearing Co.

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Oakley Chemical Co.

Compounds, Cutting
Oakley Chemical Co.

Conduits and Fittings, Electrical
National Metal Molding Co.
Titeflex Metal Hose Corp.

Connecting-Rods
Anderson Forge & Machine Co.
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Park Drop Forge Co.
Savage Arms Corp.
Williams, J. H., & Co.

Connections, Tire Pump
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New Process Gear Corp.
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Engines, Marine
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Weidely Motors Co.
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Fans, Radiator Cooling
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Hydraulic Pressed Steel Co.
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Gages, Tire Pressure
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Gaskets
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McCord Mfg. Co., Inc.

Gaskets, Cork
Armstrong Cork Co.

Gaskets, Fiber
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Gasoline
Texas Co.

Gear Shifting Devices
United States Auto Gear Shift Co.

Gears
Anderson Forge & Machine Co.
Crofoot Gear Works, Inc.
Link-Belt Company
Morse Chain Co.
New Process Gear Corp.
Ross Gear & Tool Co.
Savage Arms Corp.
Van Dorn & Dutton Co.
Wyman-Gordon Co.

Gears, Differential
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Gears, Speedometer
Van Dorn & Dutton Co.

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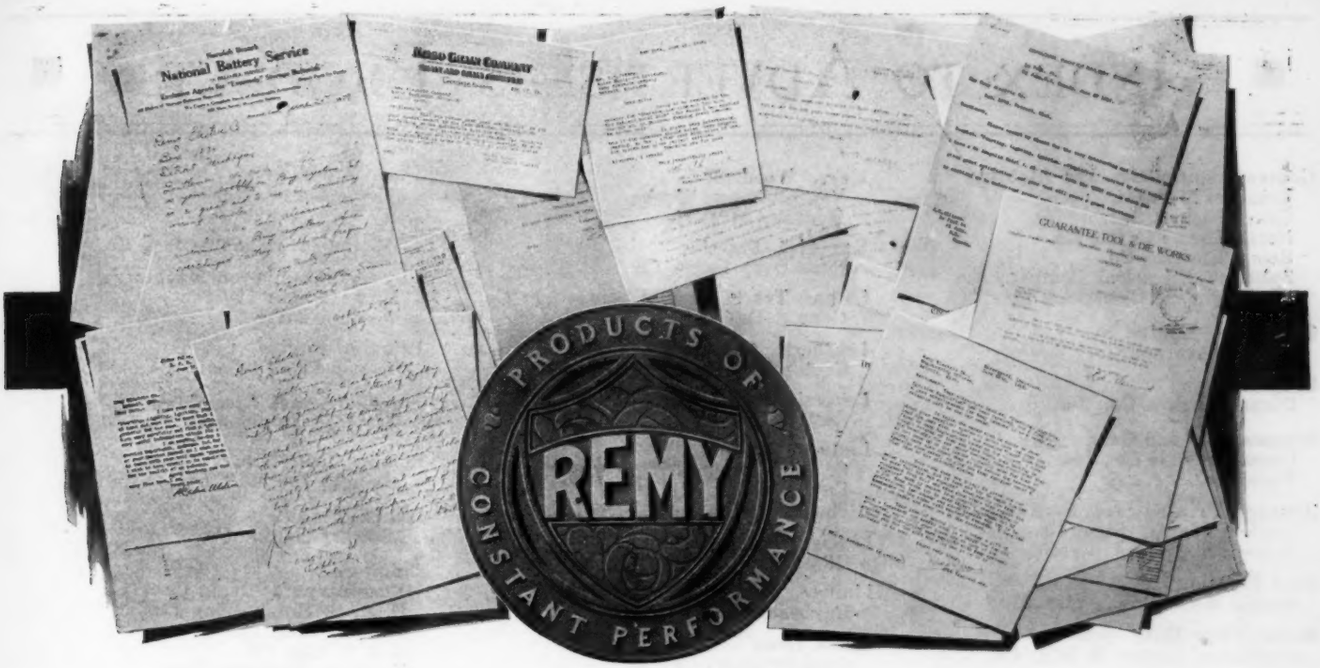

What Does the Name Remy Really Mean to the Motorist?

Accurately to gauge the attitude of millions of motorists toward Remy Starting, Lighting and Ignition Systems has been one of our chief self-assigned tasks throughout the year now drawing to a close.

We have propounded to ourselves the question, "What does the name Remy really mean to the motorist?"—and have insisted on an answer based *other* than in terms of sales made or corporate profits earned.

The answer is now known—hurled back at us by countless thousands of veteran Remy users.

Men who have gladly picked up the subtle gauntlet thrown down in our national advertising—and of their own accord expressed their preference and enthusiasm for Remy quality and constancy of performance.

It is this *universal satisfaction* on the part of motorists who know their Remy systems that gives the answer to our question.

Possibly this will help *you* to understand why the Remy-equipped motor car is an easier car to sell—and keep sold throughout its years of service.

Remy Electric Company

General Offices and Factory: Anderson, Indiana

REMY

STARTING LIGHTING IGNITION SYSTEMS

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Knuckles, Steering
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Jaxon Steel Products Co.
Standard Parts Co.

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Jaxon Steel Products Co.

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Automotive Products Corp.
Piston Ring Co.
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Spicer Mfg. Corp.

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Remy Electric Co.
Splitdorf Electrical Co.
Westinghouse Electric & Mfg. Co.

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Interstate Iron & Steel Co.

Steel, Cold Drawn
Columbia Steel & Shafting Co.
Lancaster Steel Products Co.
Union Drawn Steel Co.

Steel, Crucible
Marlin-Rockwell Corp.

Steel, Electric Furnace
Simonds Mfg. Co.
United Alloy Steel Corp.

Steel, High Speed
Marlin-Rockwell Corp.

Steel, Nickel
Columbia Steel & Shafting Co.
Interstate Iron & Steel Co.
Lancaster Steel Products Co.
United Alloy Steel Corp.

Steel, Screw
Columbia Steel & Shafting Co.
Union Drawn Steel Co.

Steel, Silico-Manganese
Interstate Iron & Steel Co.
United Alloy Steel Corp.

Steel, Strip
Lancaster Steel Products Co.

Steel, Tool
Lancaster Steel Products Co.

Strapping
Graton & Knight Mfg. Co.

Switchboards, Charging
Electric Storage Battery Co.

Switches, Lighting and Starting
Westinghouse Electric & Mfg. Co.

Tacks
Interstate Iron & Steel Co.

Tanks, Air
Janney, Steinmetz & Co.

Tanks, Gasoline
Janney, Steinmetz & Co.

Timers
Splitdorf Electrical Co.

Tire Accessories
Firestone Steel Products Co.

Tires, Pneumatic and Solid
Firestone Steel Products Co.
Goodyear Tire & Rubber Co.
Kelly-Springfield Tire Co.

Tool Holders
Williams, J. H., & Co.

Torsion-Rod Assemblies
Steel Products Co.

Tractors
Automotive Products Corp.
Midwest Engine Co.

Transmissions
Brown-Lipe Gear Co.
C. A. S. Engineering Co.
Link-Belt Co.
Morse Chain Co.
Savage Arms Corp.

Trucks
Automotive Products Corp.

Trucks, Electric Industrial
Automotive Products Corp.

Tubes, Inner Tire
Firestone Steel Products Co.

Tubing, Fiber
American Vulcanized Fibre Co.

Tubing, Flexible Metallic
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Tubing, Helical
Rome-Turney Radiator Co.

Tubing, Rubber
Thermoid Rubber Co.

Tubing, Steel
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Standard Parts Co.

Turbines, Steam
Midwest Engine Co.

Valves, Poppet
Rich Tool Co.
Steel Products Co.
Toledo Steel Products Co.

Valves, Tire
Schrader's Son, Inc., A.

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Nagel Electric Co., W. G.
Westinghouse Electric & Mfg. Co.
Weston Electrical Instrument Co.

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Armstrong Cork Co.

Washers, Fiber
American Vulcanized Fibre Co.

Washers, Lock
Victor Screw Works

Washers, Special
Kales Stamping Co.

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Steel Products Co.

Welding Outfits, Oxy-acetylene
Steel Products Co.

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Standard Steel Castings Co.

Wheels, Cushion
Jaxon Steel Products Co.

Wheels, Motor Truck
Automotive Wood Wheel Mfrs. Ass'n
Detroit Pressed Steel Co.
Jaxon Steel Products Co.
Standard Steel Castings Co.

Wheels, Pressed Steel
Detroit Pressed Steel Co.

Wheels, Sprocket
Link-Belt Co.
Whitney Mfg. Co.

Wheels, Wire
Marlin-Rockwell Corp.

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The Index to Advertisers' Products

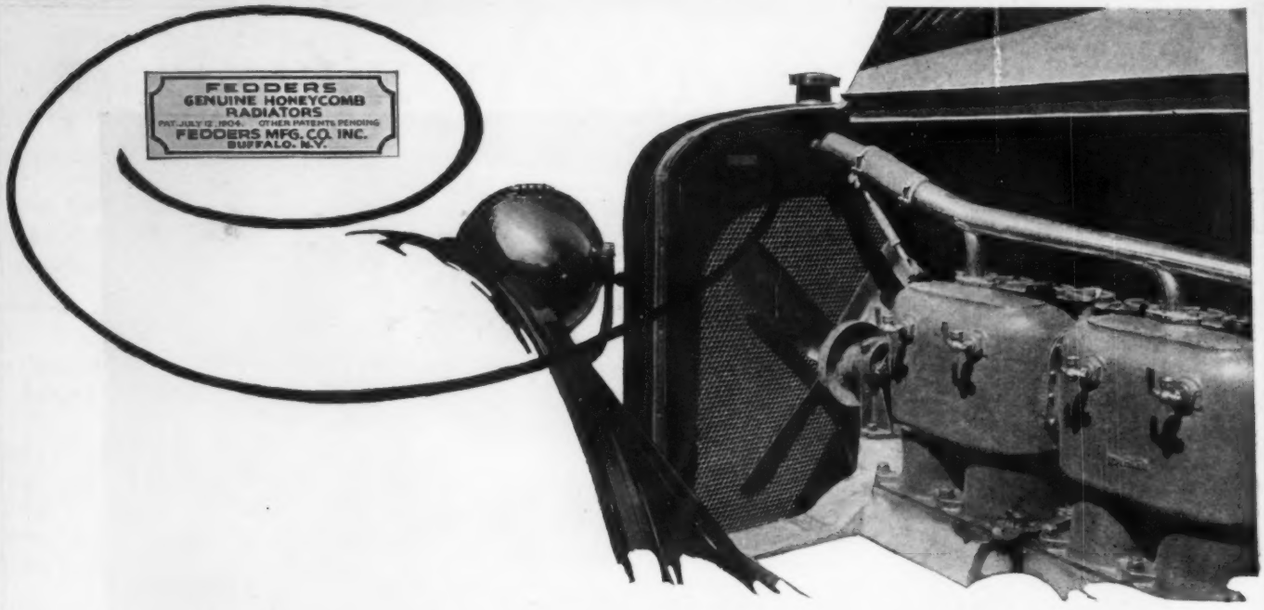
contains an alphabetically arranged classification of various products of interest to members of the Society.

The listings which represent the products of well-known companies that advertise regularly in the Journal are designed to cover, as far as possible, the needs of the different branches of the automotive industry.

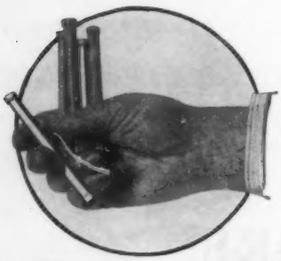
Members in search of possible sources of supply for parts or materials are referred to this section as a convenient means of meeting their requirements.

This section contains approximately 260 headings, covering the products of 145 firms.

It is found in this issue on pages 104, 106, 108 and 110.



Look for this Nameplate
on the Car You Buy



The core is composed wholly of individual Cellular Tubes placed in a horizontal position and joined at their expanded ends.

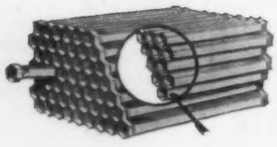
—**it is proof** that the car builder has paid more than the competitive price to ensure utmost radiator service and satisfaction for you;

—**it is a guarantee** of the many advantages peculiar to the genuine honeycomb type—the radiator composed of individual cell-like tubes, not sheets joined together to look like tubes;

—**it means full 100% in cooling efficiency** all the time—protection against clogging, leakage, or damage through freezing; and the easiest of all radiators to repair.

—**and this is the same radiator** standardized by the U. S. Government for aeroplane service—the severest test of radiator merit.

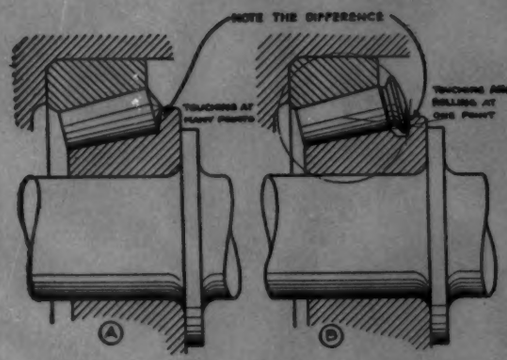
FEDDERS MFG. CO. Inc. **Buffalo, N. Y**



Note the large and uniform water spaces, made possible only by Fedders Individual Tube construction.

BOCK
TAPER ROLLER
TRADE MARK
BEARINGS

The Difference is in the Design



THE inherent principle of the taper roller bearing adapts it to carry both radial and thrust loads, a combination which occurs in most places where bearings are used. Furthermore taper roller bearings are adjustable, a factor which makes for longer life and better service, as it is thus possible to compensate for wear and eliminate undesirable play.

Now, in addition to sharing in all of the advantages common to taper roller bearings, Bock Bearings possess certain exclusive patented features which give them a further superiority.

The cut "A", at the left, represents ordinary taper roller bearing design. A brief analysis of this shows that there is bound to be rubbing action on the end of the roll. This produces friction and wear and tends to drag the roll out of axial alignment. This effect increases with the intensity of the thrust to a degree that seriously impairs the life of the bearing.

The cut "B" shows the principle of the Bock patented bearing. In this design it can be seen that the spherical ground head of the roll touches at but one point and that the proper one for pure rolling action. Consequently there is no tendency to drag the rolls out of alignment, and friction and wear are reduced to a minimum.

In workmanship, material, heat treatment and uniformity Bock Taper Roller Bearings are unexcelled, as they are likewise unequalled in design.

THE BOCK BEARING COMPANY, TOLEDO, OHIO

DIVISION OF

THE STANDARD PARTS COMPANY

EXECUTIVE OFFICES, CLEVELAND

Stan-Par Axles
Bock Bearings

Stan-Par Springs (Perfection)
Stanweld Rims, Tubing, Etc.

TRADE MARK
Stan-Par
Products